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PATENT & TRADEMARK OFFICE
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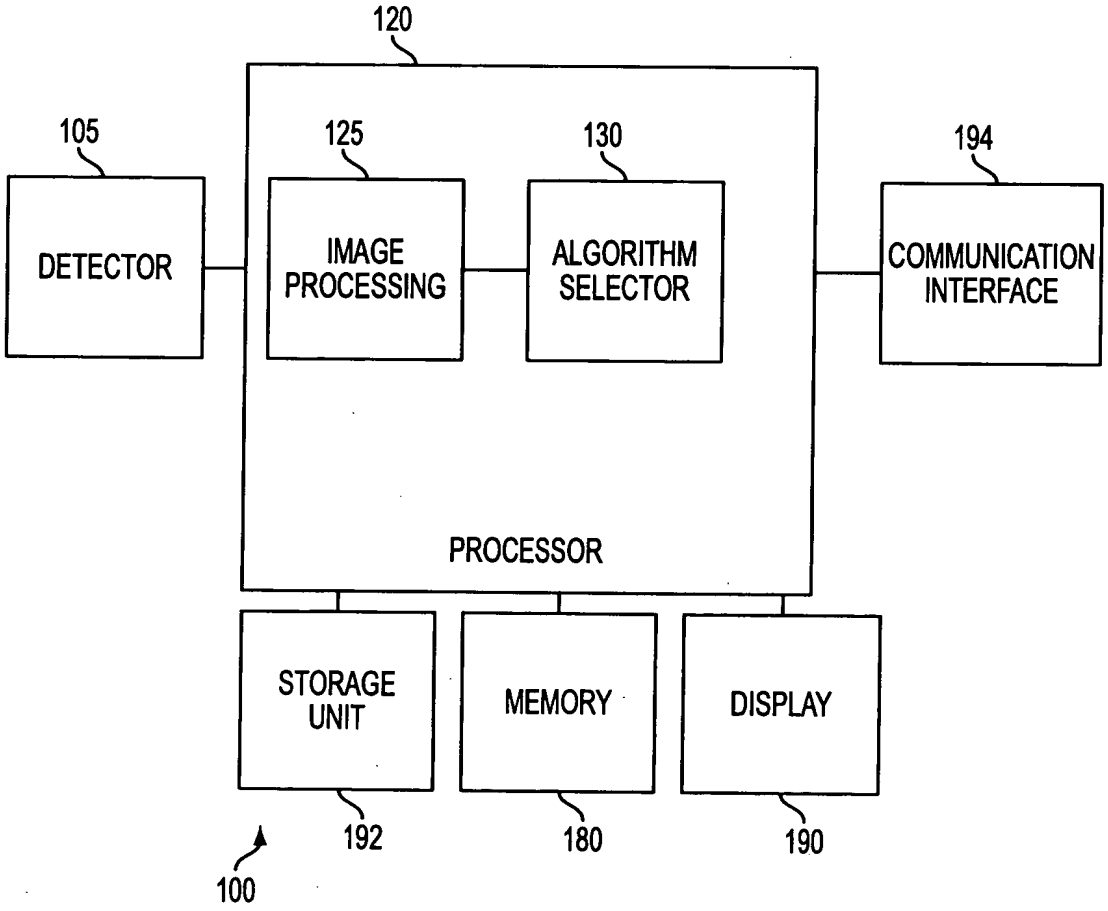


FIG. 1

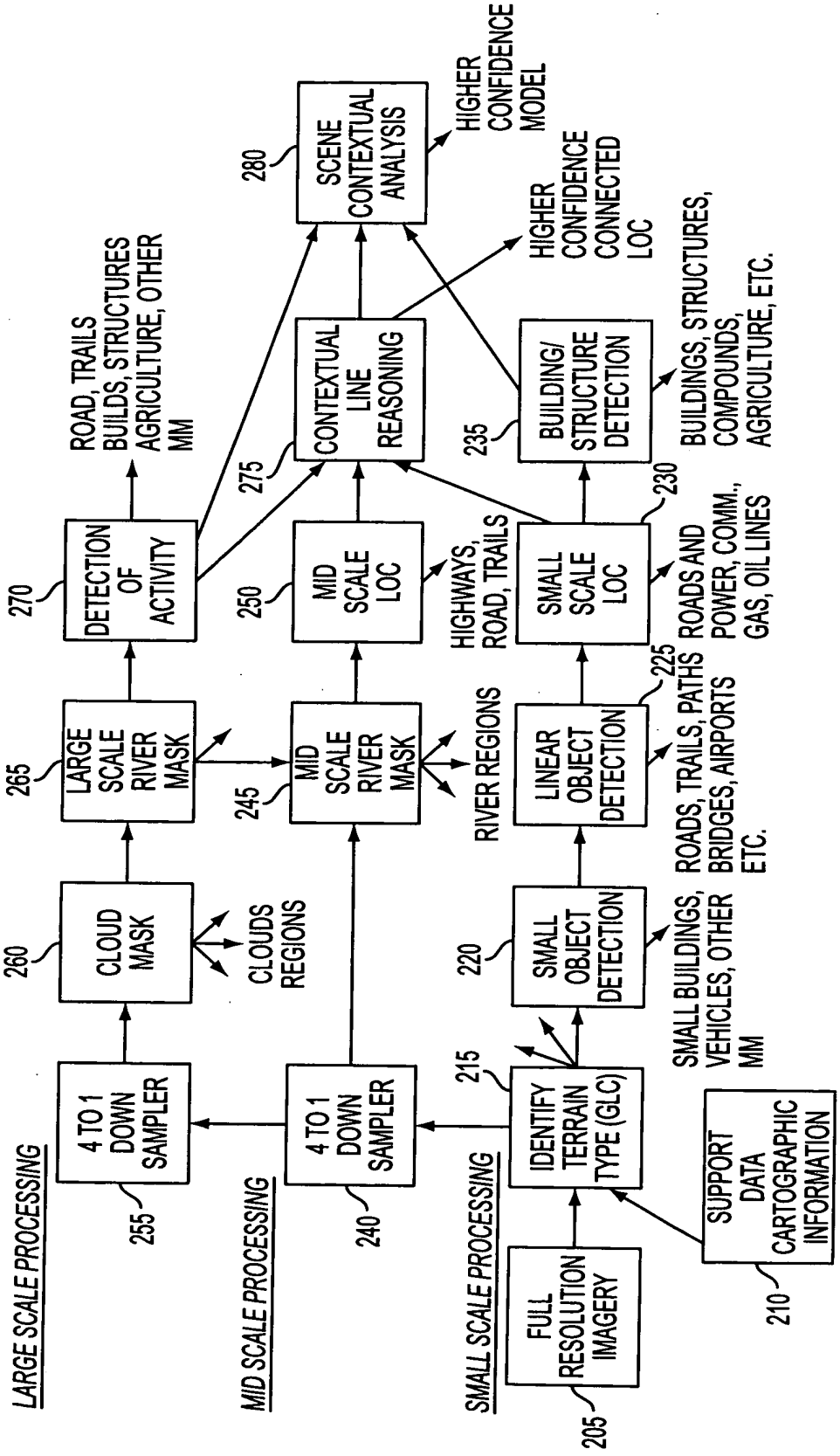

LARGE SCALE PROCESSING
MID SCALE PROCESSING
SMALL SCALE PROCESSING
FULL RESOLUTION IMAGERY
205
SUPPORT DATA CARTOGRAPHIC INFORMATION
210
IDENTIFY TERRAIN TYPE (GLC)
215
4 TO 1 DOWN SAMPLER
255
4 TO 1 DOWN SAMPLER
240
CLOUD MASK
260
CLOUDS REGIONS
LARGE SCALE RIVER MASK
265
MID SCALE RIVER MASK
245
RIVER REGIONS
SMALL OBJECT DETECTION
220
SMALL BUILDINGS, VEHICLES, OTHER MM
LINEAR OBJECT DETECTION
225
ROADS, TRAILS, PATHS BRIDGES, AIRPORTS ETC.
DETECTION OF ACTIVITY
270
ROAD, TRAILS BUILDS, STRUCTURES AGRICULTURE, OTHER MM
MID SCALE LOC
250
HIGHWAYS, ROAD, TRAILS
SMALL SCALE LOC
230
ROADS AND POWER, COMM., GAS, OIL LINES
CONTEXTUAL LINE REASONING
275
HIGHER CONFIDENCE CONNECTED LOC
BUILDING/ STRUCTURE DETECTION
235
BUILDINGS, STRUCTURES, COMPOUNDS, AGRICULTURE, ETC.
SCENE CONTEXTUAL ANALYSIS
280
HIGHER CONFIDENCE MODEL

FIG. 2

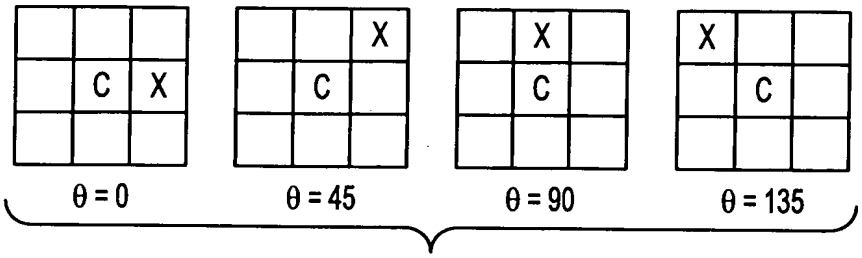


FIG. 3

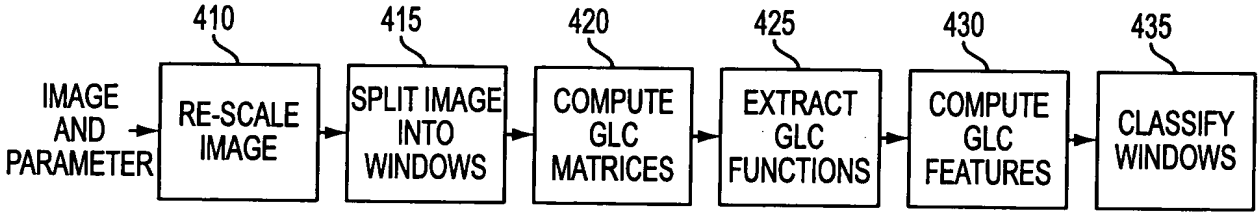


FIG. 4

ENERGY

$$En = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} (G(i,j))^2$$

ENTROPY

$$Et = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} (G(i,j) \log(G(i,j))$$

CONTRAST

$$Ct = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} (G(i,j) \times (i-j)^2)$$

INVERSE_DIFFERENCE_MOMENT

$$En = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} \frac{G(i,j)}{1+(i-j)^2}$$

CORRELATION

$$Cr = \sum_{i=0}^{n-1} \sum_{j=0}^{n-1} \frac{i \times j \times G(i,j) - \mu_x \times \mu_y}{\sigma_x \times \sigma_y}$$

FIG. 5

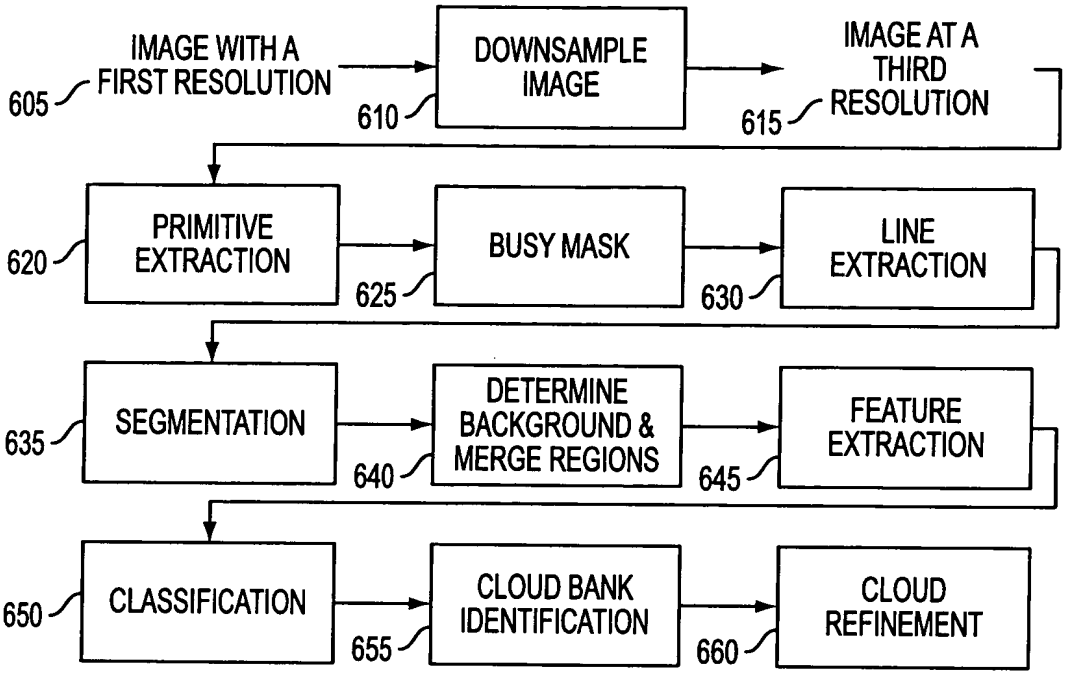


FIG. 6

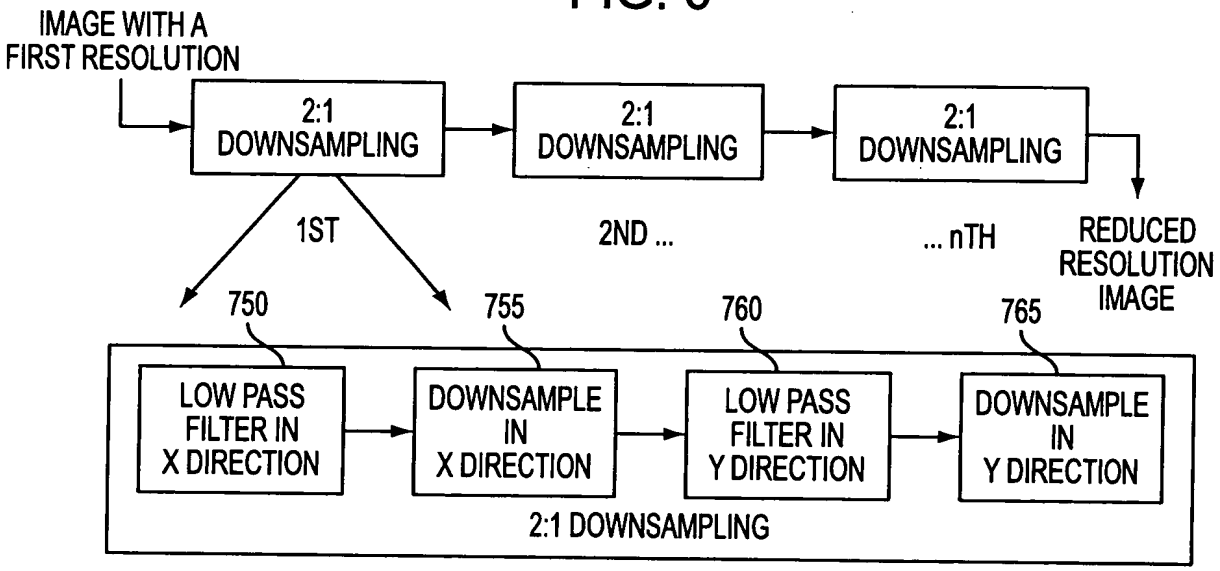


FIG. 7A

1	4	6	4	1
1	16	24	16	1
1	24	36	24	1
1	16	24	16	1
1	4	6	4	1

FULL 6 BY 6 CONVOLUTION FILTER

FIG. 7B

1	4	6	4	1

X DIRECTION FILTER

1
4
6
4
1

Y DIRECTION FILTER

FIG. 7C

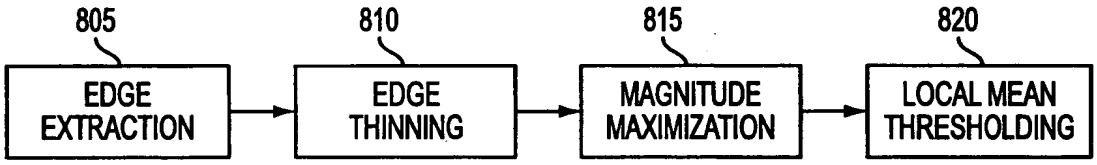


FIG. 8

-1 -2 -1	-1 0 1	4 5 6
0 0 0	-2 0 2	3 * 7
1 2 1	-1 0 1	2 1 8
HORIZONTAL COMPONENT TEMPLATE	VERTICAL COMPONENT TEMPLATE	DIRECTIONAL MAPPING

D_x = CONVOLUTION OF THE VERTICAL TEMPLATE WITH THE IMAGE

D_y = CONVOLUTION OF THE HORIZONTAL TEMPLATE WITH THE IMAGE

$$\text{SOBEL MAGNITUDE} = (D_x^2 + D_y^2)^{1/2}$$

SOBEL DIRECTION = ARCTAN (D_y / D_x) MAPPED TO 8 DIRECTIONS

FIG. 9A

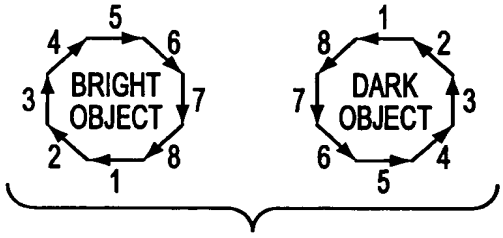


FIG. 9B

DIRECTIONS 3 & 7	DIRECTIONS 1 & 5	DIRECTIONS 2 & 6	DIRECTIONS 4 & 8
O O O O O	O X X X O	O O O X O	O X O O O
X O O O X	O O X O O	O O O X X	X X O O O
X X C X X	O O C O O	O O C O O	O O C O O
X O O O X	O O X O O	X X O O O	O O O X X
O O O O O	O X X X O	O X O O O	O O O X O

C = CENTER PIXEL X = NON-ZERO PIXEL O = DON'T CARE PIXEL

FIG. 10

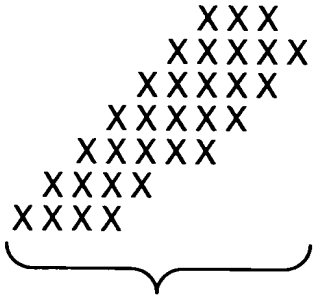


FIG. 11A

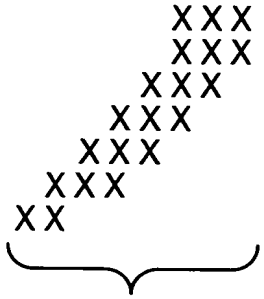


FIG. 11B

X 1 X	X 1 X	X X O	O X X
X C 1	1 C X	1 C X	X C 1
O X X	X X O	X 1 X	X 1 X

1 = NON-ZERO PIXEL, O = ZERO PIXEL, X = DON'T CARE

FIG. 12

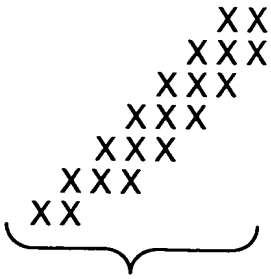


FIG. 13A

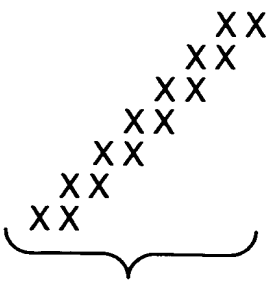


FIG. 13B

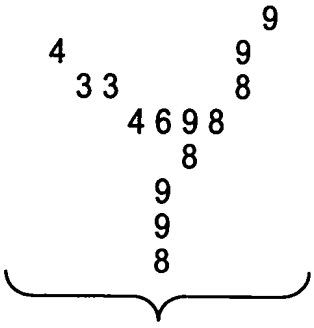


FIG. 14A

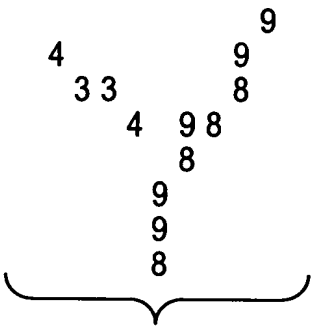


FIG. 14B

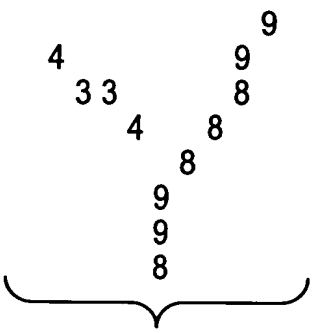


FIG. 14C

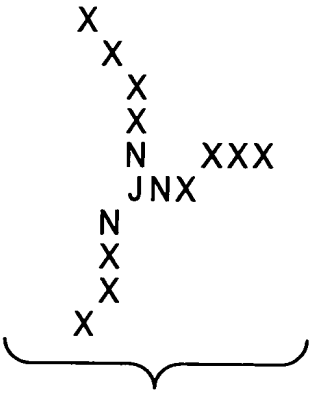


FIG. 15A

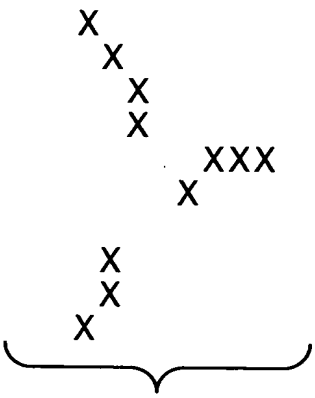


FIG. 15B

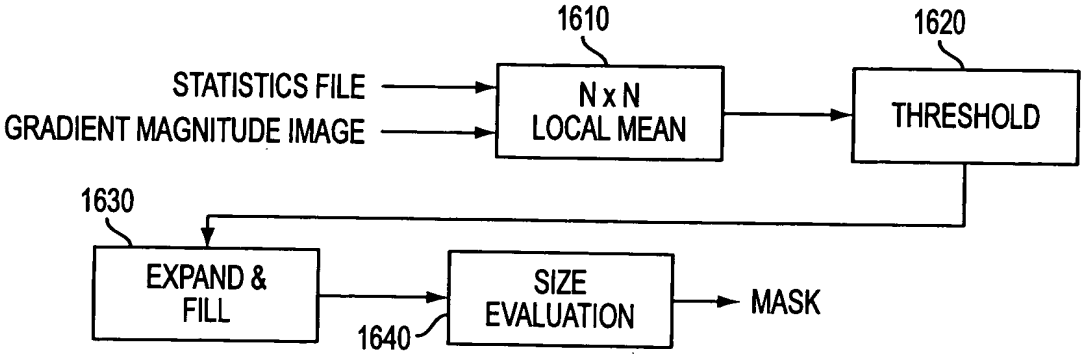


FIG. 16

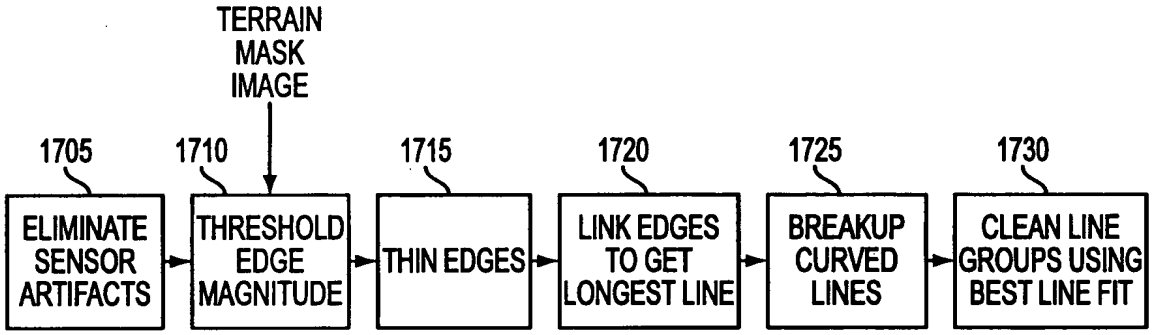
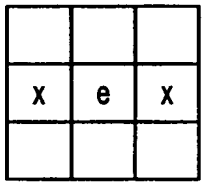
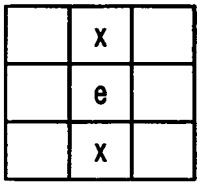


FIG. 17



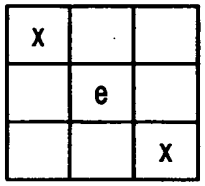
3 AND 7

FIG. 18A



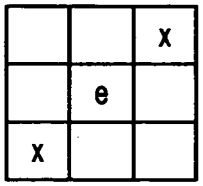
1 AND 5

FIG. 18B



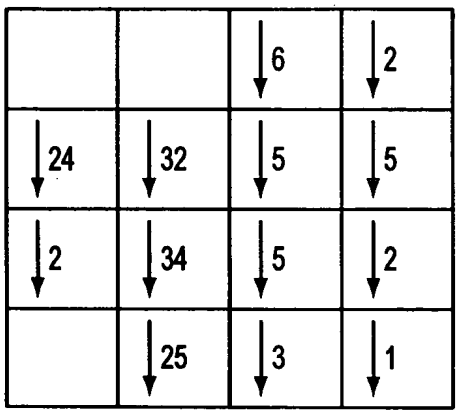
4 AND 8

FIG. 18C



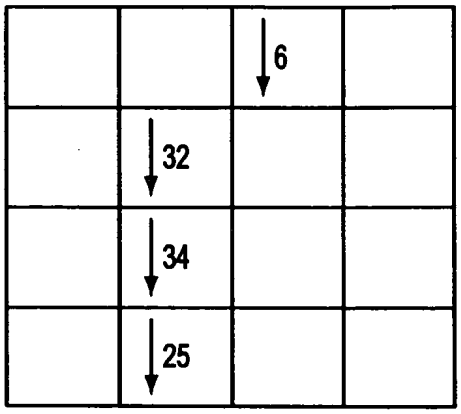
2 AND 6

FIG. 18D



EDGES DIRECTIONS AND MAGNITUDES

FIG. 19A



THINNING EDGES

FIG. 19B

1	1	1	1	1	1	1	1	

NO NOISE PRESENT

FIG. 20A

1	2	1	1	1	1	2	2	1	1	1	8	1

NOISE PRESENT

FIG. 20B

REGIONS	1	2	3				4		5			6	7
EDGE DIRECTION	1	2	1	1	1	1	2	2	1	1	1	8	1
A) NON-OVERLAPPING REGION	1	1	1	1	1	1	1	1	1	1	1	8	1
B) NON-OVERLAPPING REGION	8	2	8	8	8	8	2	2	8	8	8	8	8

DIRECTION 1 = DIRECTION 1 AND DIRECTION 2
DIRECTION 2 = DIRECTION 2 AND DIRECTION 3
DIRECTION 3 = DIRECTION 3 AND DIRECTION 4
DIRECTION 4 = DIRECTION 4 AND DIRECTION 5
DIRECTION 5 = DIRECTION 5 AND DIRECTION 6
DIRECTION 6 = DIRECTION 6 AND DIRECTION 7
DIRECTION 7 = DIRECTION 7 AND DIRECTION 8
DIRECTION 8 = DIRECTION 8 AND DIRECTION 1

FIG. 20C

FIG. 21A

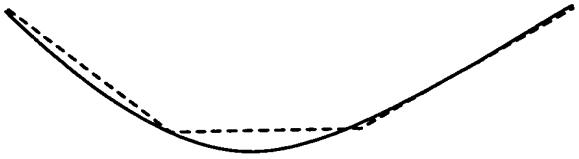


FIG. 21B

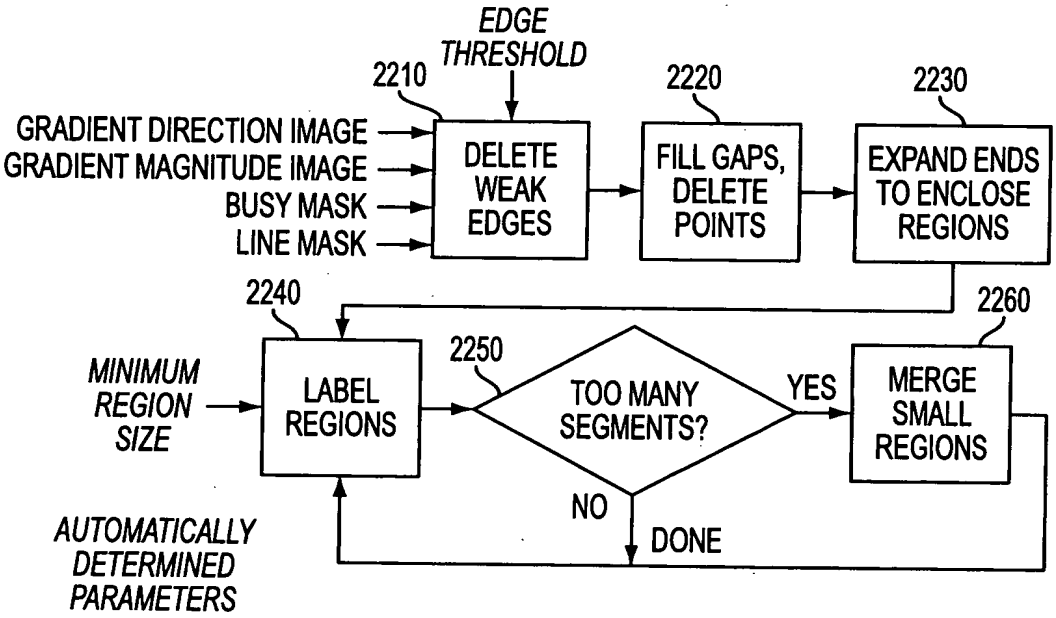


FIG. 22

E E O O E E O E O O E O
O C O O C O O C O O C O
O E O O E O E E O O E E

TEMPLATES FOR VERTICAL POINT GAP

C = CENTER PIXEL, VALUE 1 E = PIXEL VALUE 1 O = ZERO PIXEL VALUE

E O O O O E O O O O O O
E C E E C E E C E E C E
O O O O O O E O O O O E

TEMPLATES FOR HORIZONTAL POINT GAP

FIG. 23

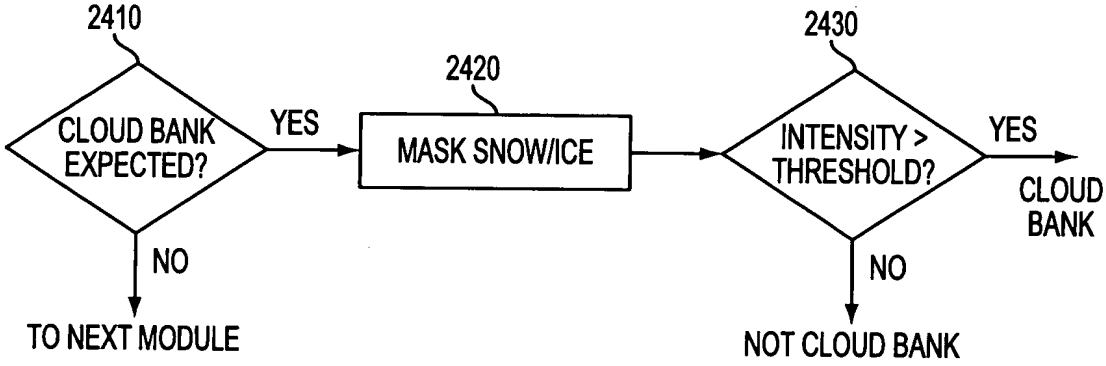

2410
CLOUD BANK EXPECTED?
YES
2420
MASK SNOW/ICE
2430
INTENSITY > THRESHOLD?
YES
CLOUD BANK
NO
TO NEXT MODULE
NO
NOT CLOUD BANK

FIG. 24

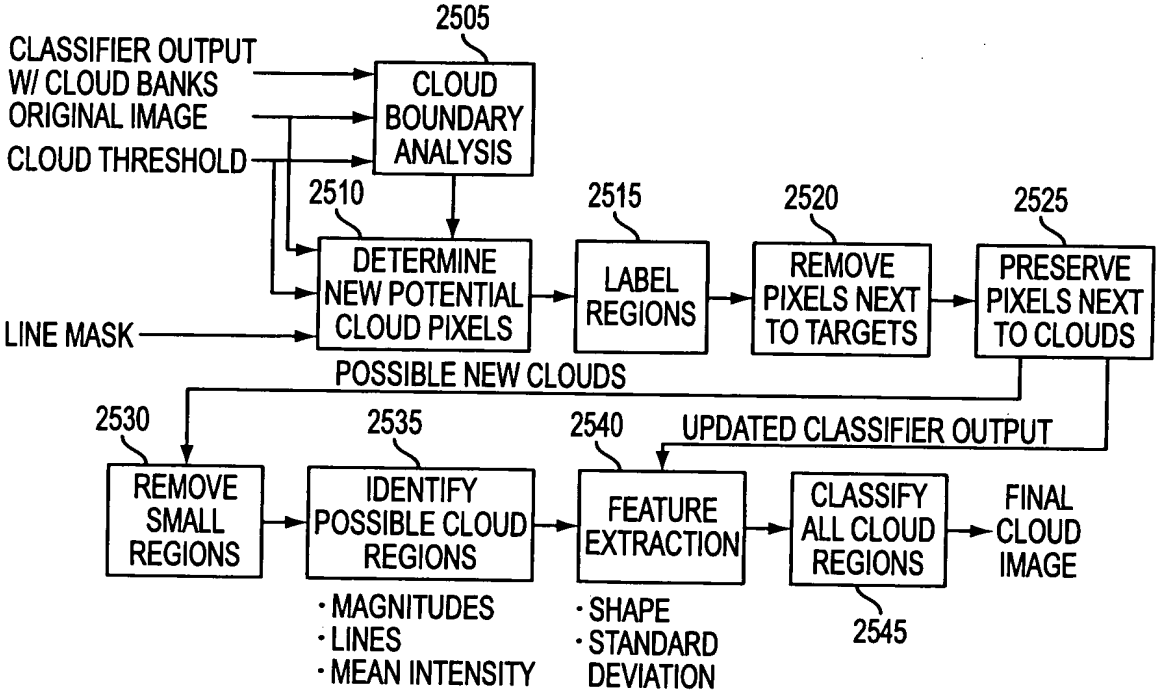

2505
CLASSIFIER OUTPUT W/ CLOUD BANKS
ORIGINAL IMAGE
CLOUD THRESHOLD
CLOUD BOUNDARY ANALYSIS
2510
DETERMINE NEW POTENTIAL CLOUD PIXELS
LINE MASK
2515
LABEL REGIONS
2520
REMOVE PIXELS NEXT TO TARGETS
2525
PRESERVE PIXELS NEXT TO CLOUDS
POSSIBLE NEW CLOUDS
2530
REMOVE SMALL REGIONS
2535
IDENTIFY POSSIBLE CLOUD REGIONS
· MAGNITUDES
· LINES
· MEAN INTENSITY
2540
UPDATED CLASSIFIER OUTPUT
FEATURE EXTRACTION
· SHAPE
· STANDARD DEVIATION
CLASSIFY ALL CLOUD REGIONS
2545
FINAL CLOUD IMAGE

FIG. 25

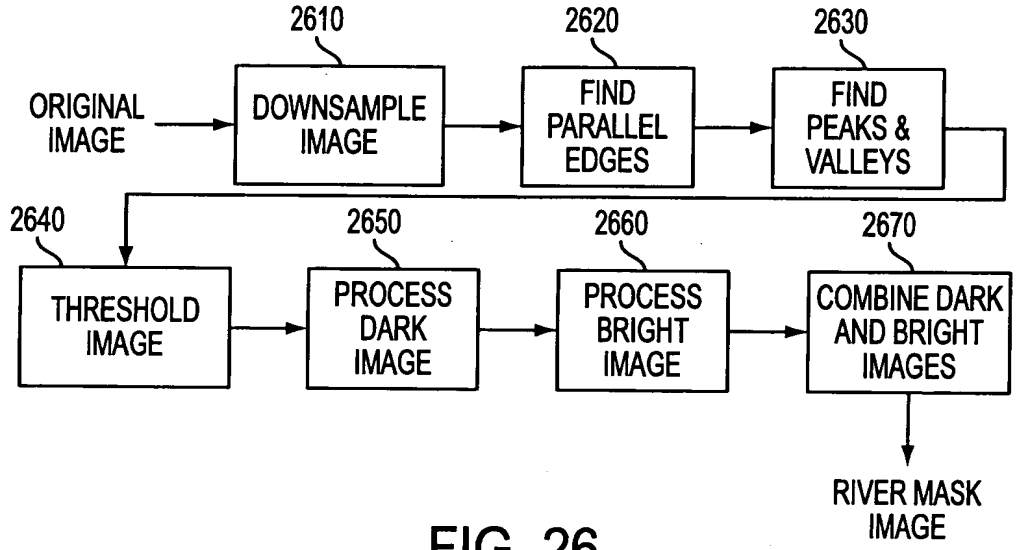

2610
2620
2630
ORIGINAL IMAGE
DOWNSAMPLE IMAGE
FIND PARALLEL EDGES
FIND PEAKS & VALLEYS
2640
2650
2660
2670
THRESHOLD IMAGE
PROCESS DARK IMAGE
PROCESS BRIGHT IMAGE
COMBINE DARK AND BRIGHT IMAGES
RIVER MASK IMAGE

FIG. 26

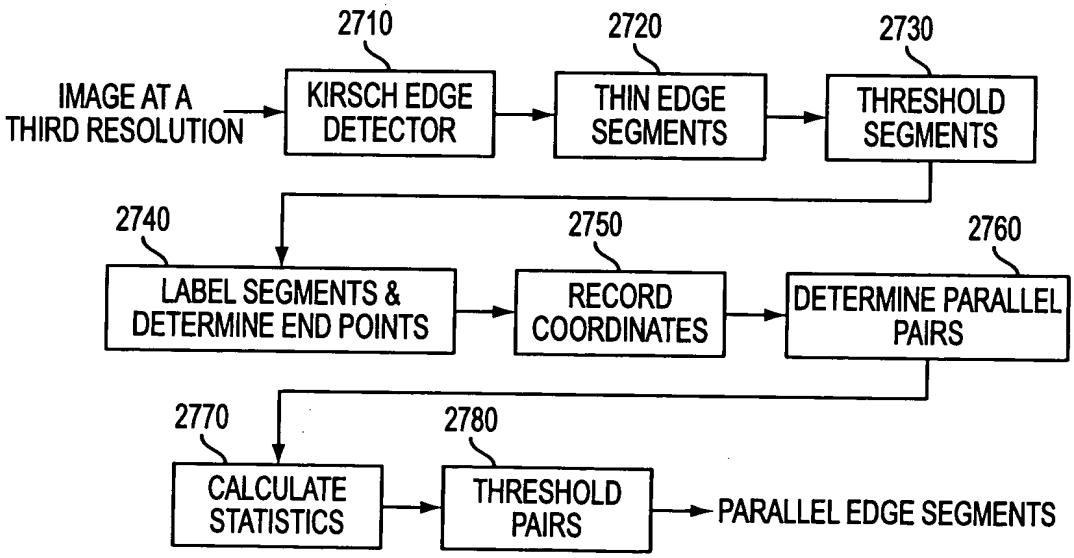

2710
2720
2730
IMAGE AT A THIRD RESOLUTION
KIRSCH EDGE DETECTOR
THIN EDGE SEGMENTS
THRESHOLD SEGMENTS
2740
2750
2760
LABEL SEGMENTS & DETERMINE END POINTS
RECORD COORDINATES
DETERMINE PARALLEL PAIRS
2770
2780
CALCULATE STATISTICS
THRESHOLD PAIRS
PARALLEL EDGE SEGMENTS

FIG. 27

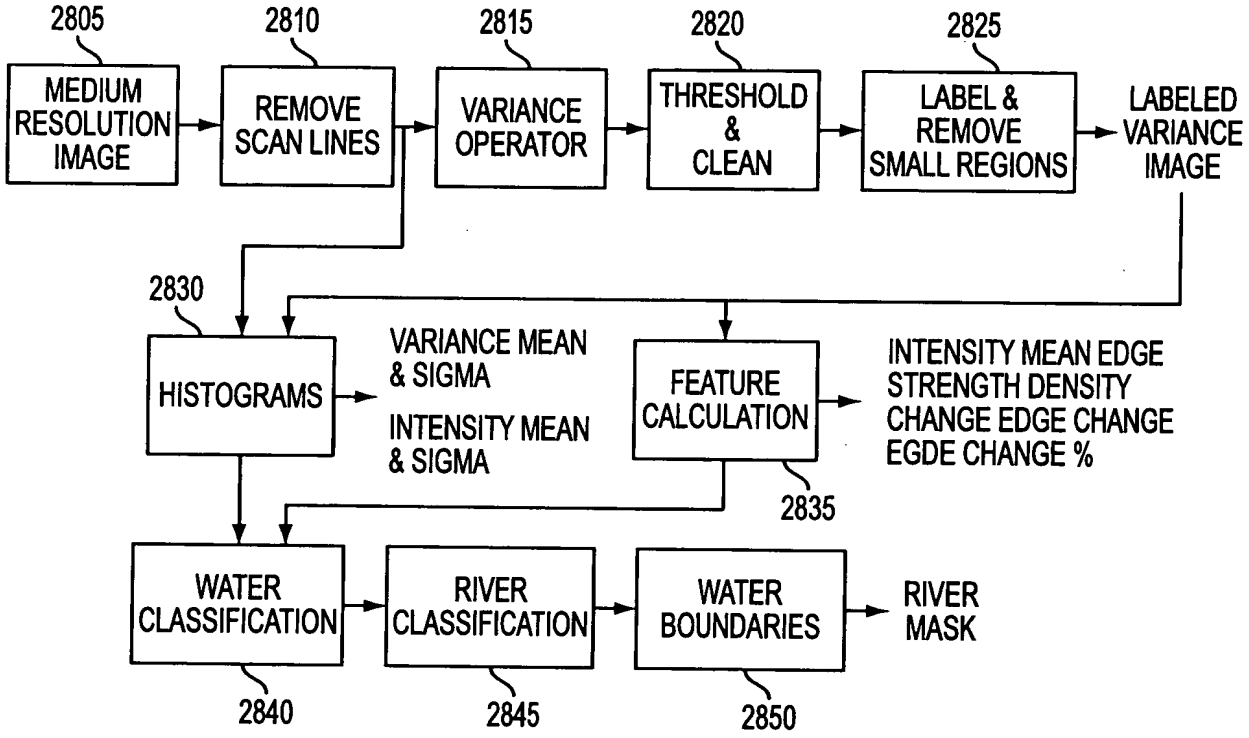


FIG. 28

$a_{-1,-1}$	$a_{0,-1}$	$a_{1,-1}$
$a_{-1,0}$	$a_{0,0}$	$a_{1,0}$
$a_{-1,1}$	$a_{0,1}$	$a_{1,1}$

3 BY 3 NEIGHBORHOOD

FIG. 29A

$$\sigma = \frac{1}{n}\sum_{j=-k}^{k}\sum_{i=-k}^{k}(a_{ij}-\mu)^2$$

WHERE

$$\mu = \frac{1}{n}\sum_{i=-k}^{k}(a_{ij})$$

3 BY 3 NEIGHBORHOOD k =1

FIG. 29B

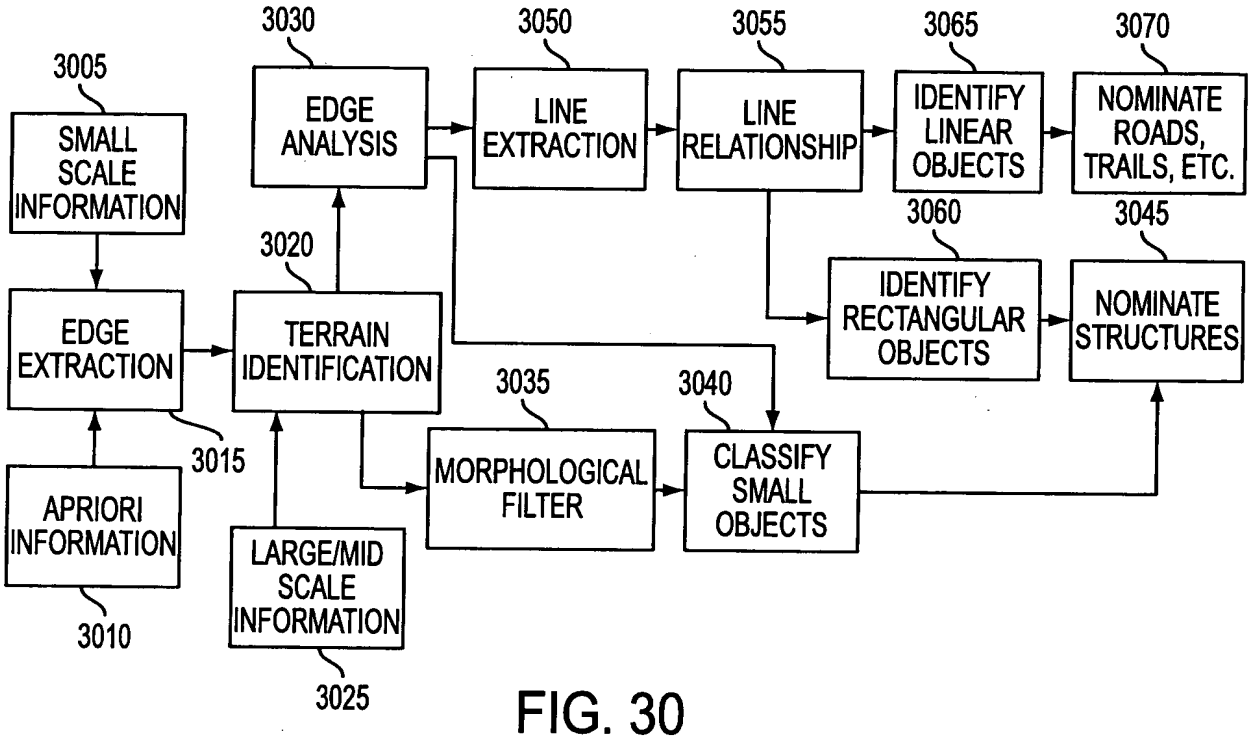

3005
SMALL SCALE INFORMATION
3030
EDGE ANALYSIS
3050
LINE EXTRACTION
3055
LINE RELATIONSHIP
3065
IDENTIFY LINEAR OBJECTS
3070
NOMINATE ROADS, TRAILS, ETC.
3060
IDENTIFY RECTANGULAR OBJECTS
3045
NOMINATE STRUCTURES
3020
EDGE EXTRACTION
TERRAIN IDENTIFICATION
3035
MORPHOLOGICAL FILTER
3040
CLASSIFY SMALL OBJECTS
3015
APRIORI INFORMATION
3010
LARGE/MID SCALE INFORMATION
3025

FIG. 30

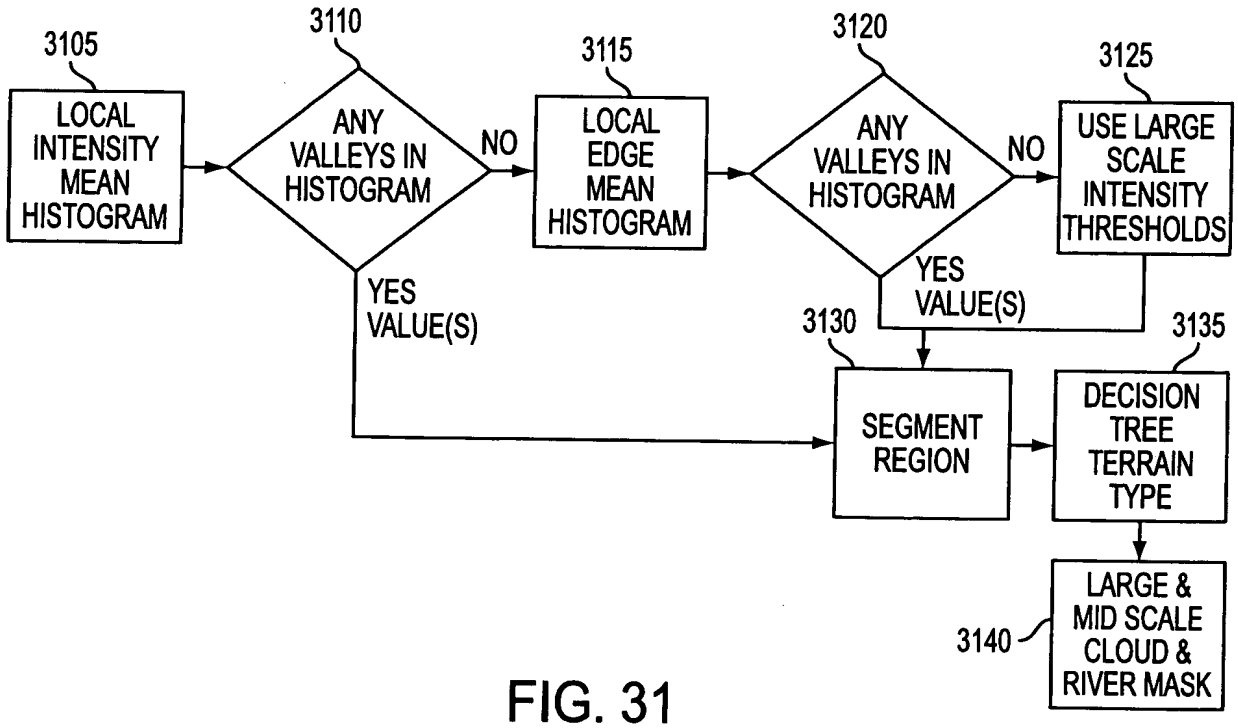

3105
LOCAL INTENSITY MEAN HISTOGRAM
3110
ANY VALLEYS IN HISTOGRAM
NO
YES
VALUE(S)
3115
LOCAL EDGE MEAN HISTOGRAM
3120
ANY VALLEYS IN HISTOGRAM
NO
YES
VALUE(S)
3125
USE LARGE SCALE INTENSITY THRESHOLDS
3130
SEGMENT REGION
3135
DECISION TREE TERRAIN TYPE
3140
LARGE & MID SCALE CLOUD & RIVER MASK

FIG. 31

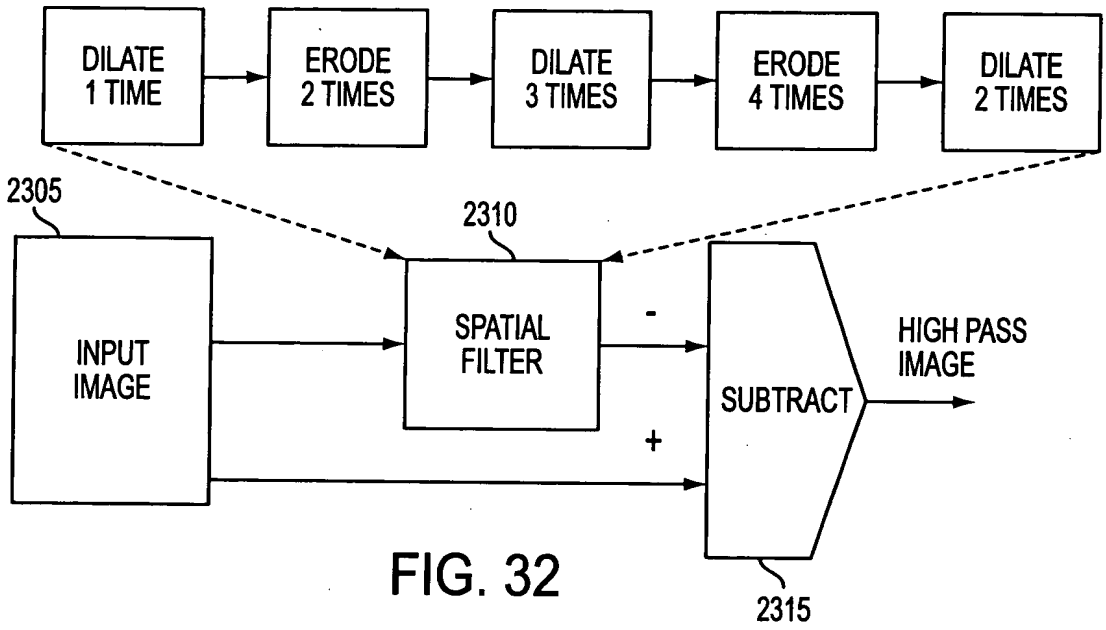
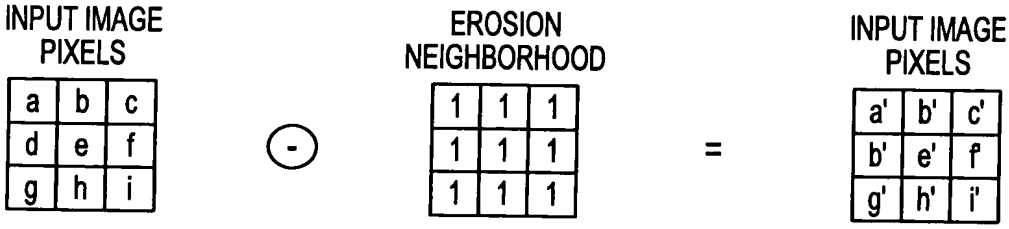


FIG. 32

WHERE e' = MAXIMUM OF { a, b, c, d, e, f, g, h, i}

FIG. 33A



WHERE e' = MINIMUM OF { a, b, c, d, e, f, g, h, i}

FIG. 33B

HORIZONTAL	VERTICAL	DIAGONAL 1	DIAGONAL 2
1 1 1	-1 0 1	0 1 1	-1 -1 0
0 0 0	-1 0 1	-1 0 1	-1 0 1
-1 -1 -1	-1 0 1	-1 -1 0	0 1 1

FIG. 34A

	HORIZONTAL		VERTICAL		DIAGONAL 1		DIAGONAL 2	
GRADIENT SIGN	+	-	+	-	+	-	+	-
DIRECTION	1	5	3	7	2	6	4	8

FIG. 34B

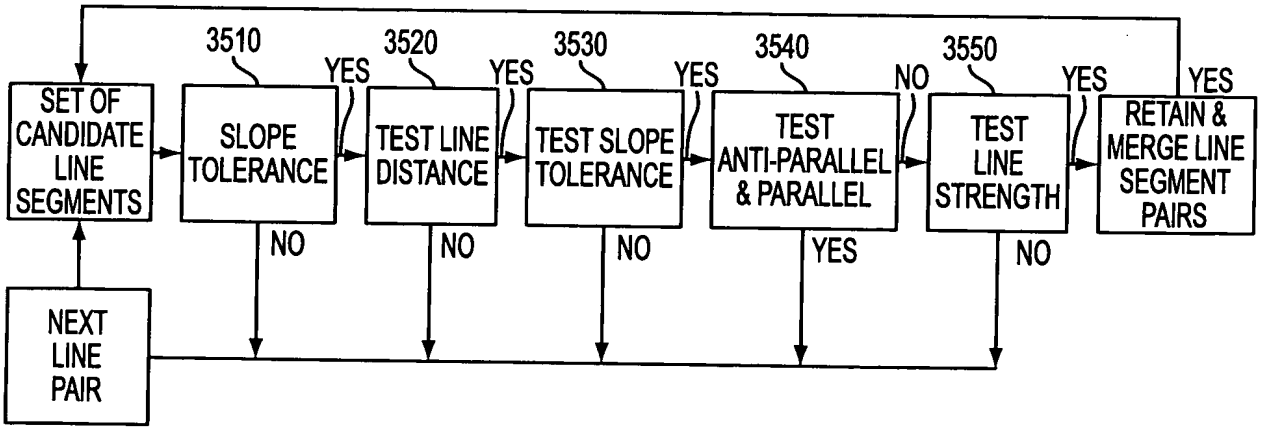


FIG. 35

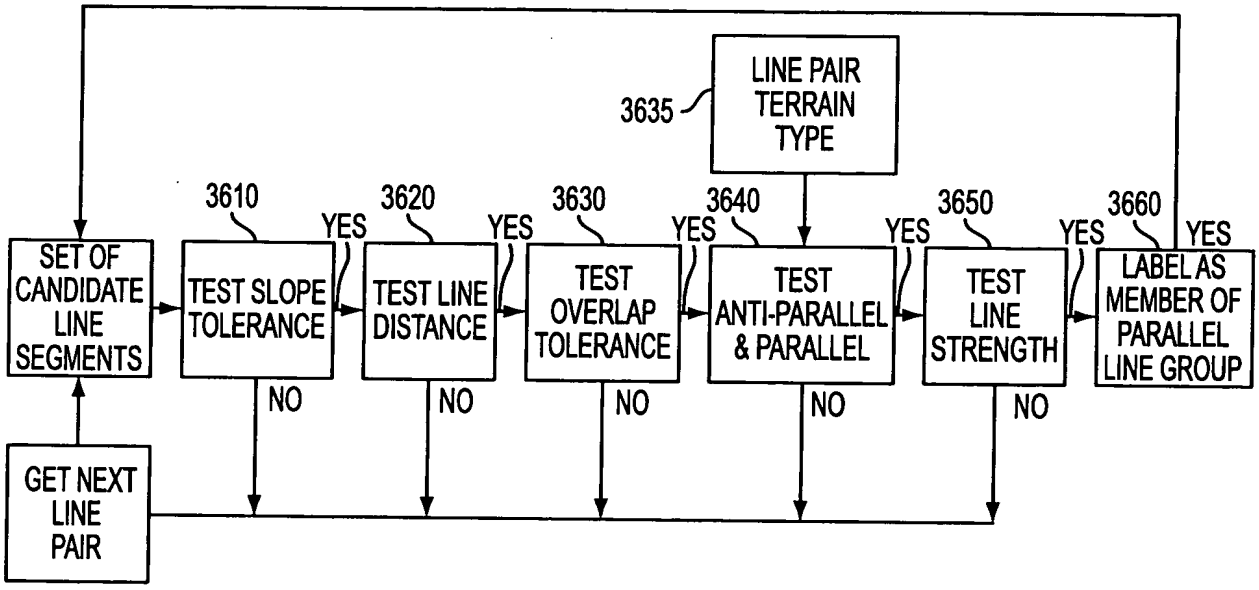

LINE PAIR TERRAIN TYPE
3635
SET OF CANDIDATE LINE SEGMENTS
3610
TEST SLOPE TOLERANCE
3620
TEST LINE DISTANCE
3630
TEST OVERLAP TOLERANCE
3640
TEST ANTI-PARALLEL & PARALLEL
3650
TEST LINE STRENGTH
3660
LABEL AS MEMBER OF PARALLEL LINE GROUP
YES
NO
GET NEXT LINE PAIR

FIG. 36

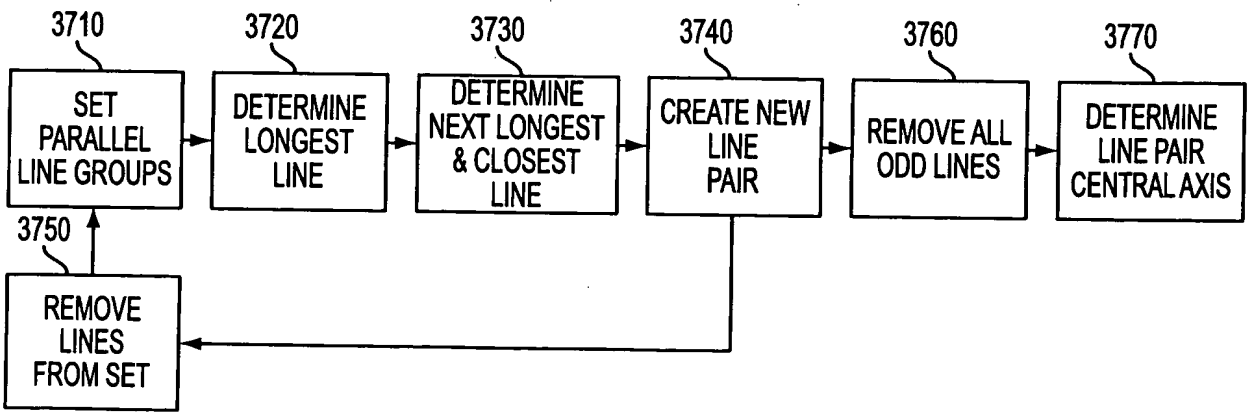

3710
SET PARALLEL LINE GROUPS
3720
DETERMINE LONGEST LINE
3730
DETERMINE NEXT LONGEST & CLOSEST LINE
3740
CREATE NEW LINE PAIR
3760
REMOVE ALL ODD LINES
3770
DETERMINE LINE PAIR CENTRAL AXIS
3750
REMOVE LINES FROM SET

FIG. 37

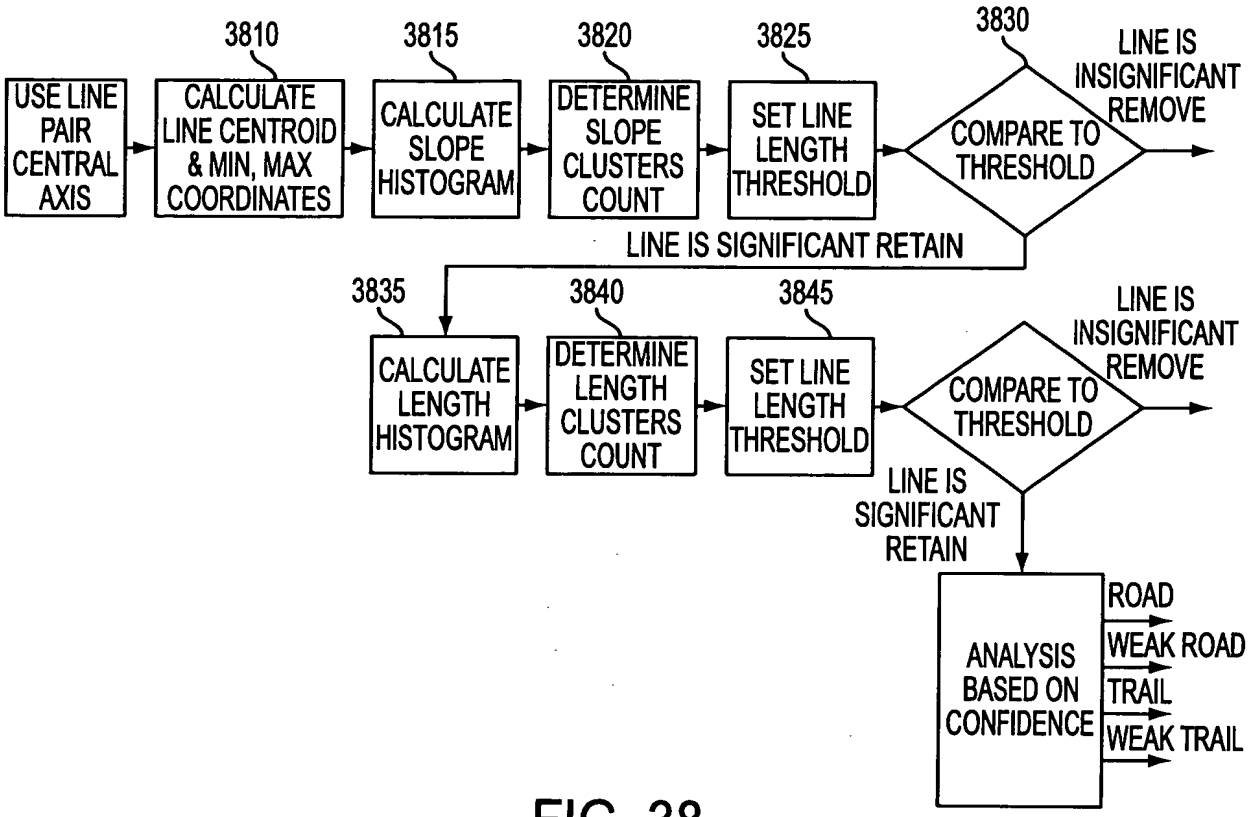

3810
3815
3820
3825
3830
USE LINE PAIR CENTRAL AXIS
CALCULATE LINE CENTROID & MIN, MAX COORDINATES
CALCULATE SLOPE HISTOGRAM
DETERMINE SLOPE CLUSTERS COUNT
SET LINE LENGTH THRESHOLD
COMPARE TO THRESHOLD
LINE IS INSIGNIFICANT REMOVE
LINE IS SIGNIFICANT RETAIN
3835
3840
3845
CALCULATE LENGTH HISTOGRAM
DETERMINE LENGTH CLUSTERS COUNT
SET LINE LENGTH THRESHOLD
COMPARE TO THRESHOLD
LINE IS INSIGNIFICANT REMOVE
LINE IS SIGNIFICANT RETAIN
ANALYSIS BASED ON CONFIDENCE
ROAD
WEAK ROAD
TRAIL
WEAK TRAIL

FIG. 38

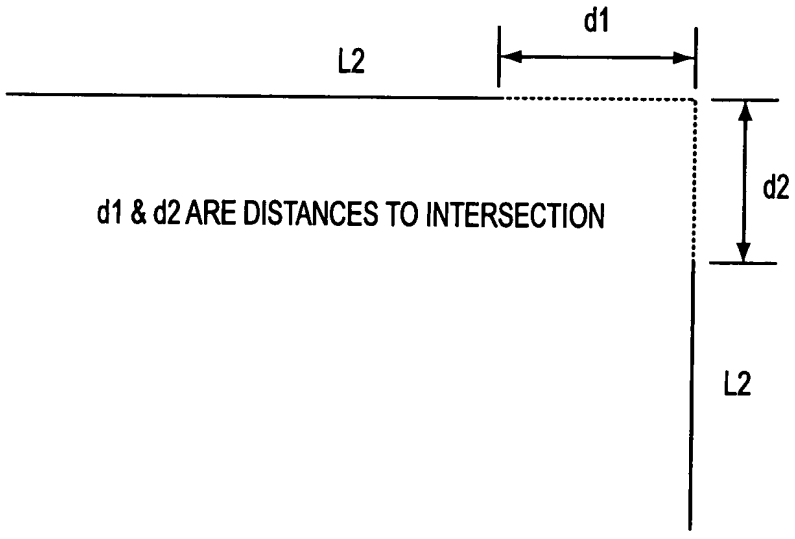

d1
L2
d2
d1 & d2 ARE DISTANCES TO INTERSECTION
L2

FIG. 39

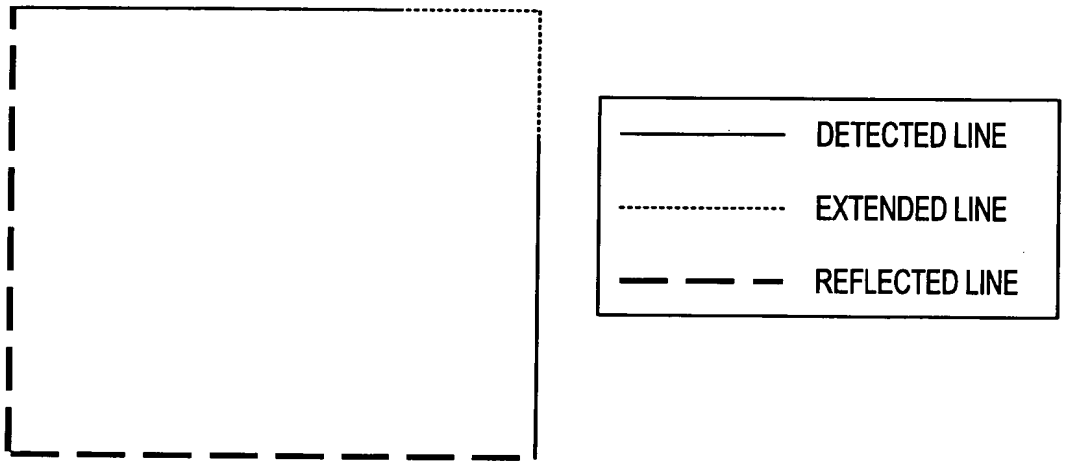


FIG. 40

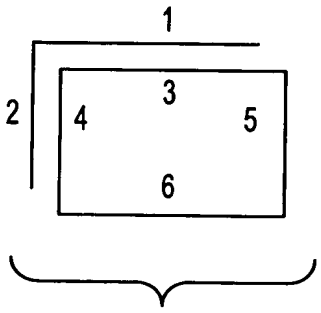


FIG. 41A

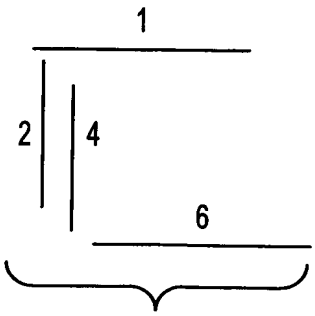


FIG. 41B

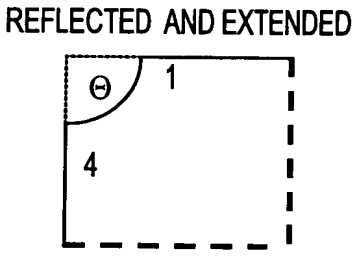


FIG. 41C

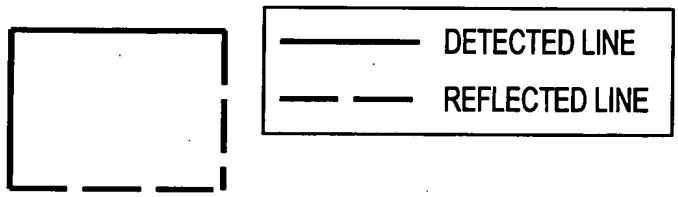


FIG. 42A

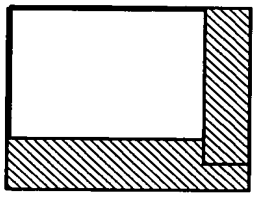


FIG. 42B

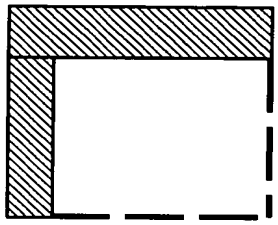


FIG. 42C

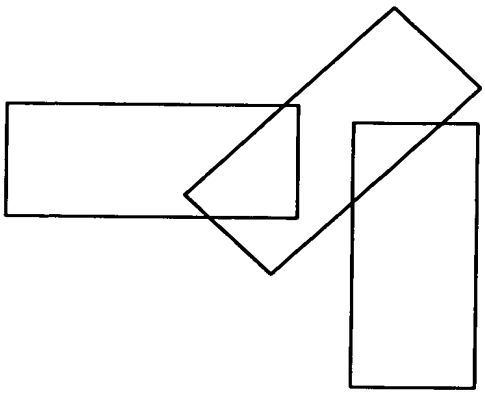


FIG. 43A

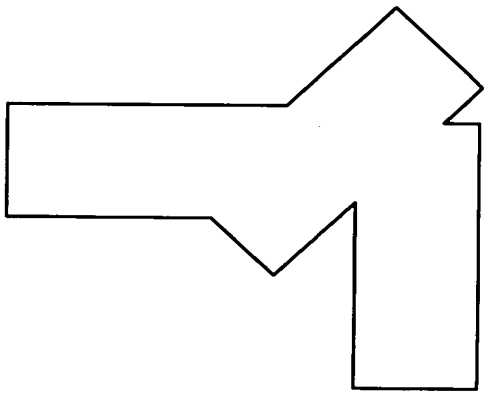


FIG. 43B

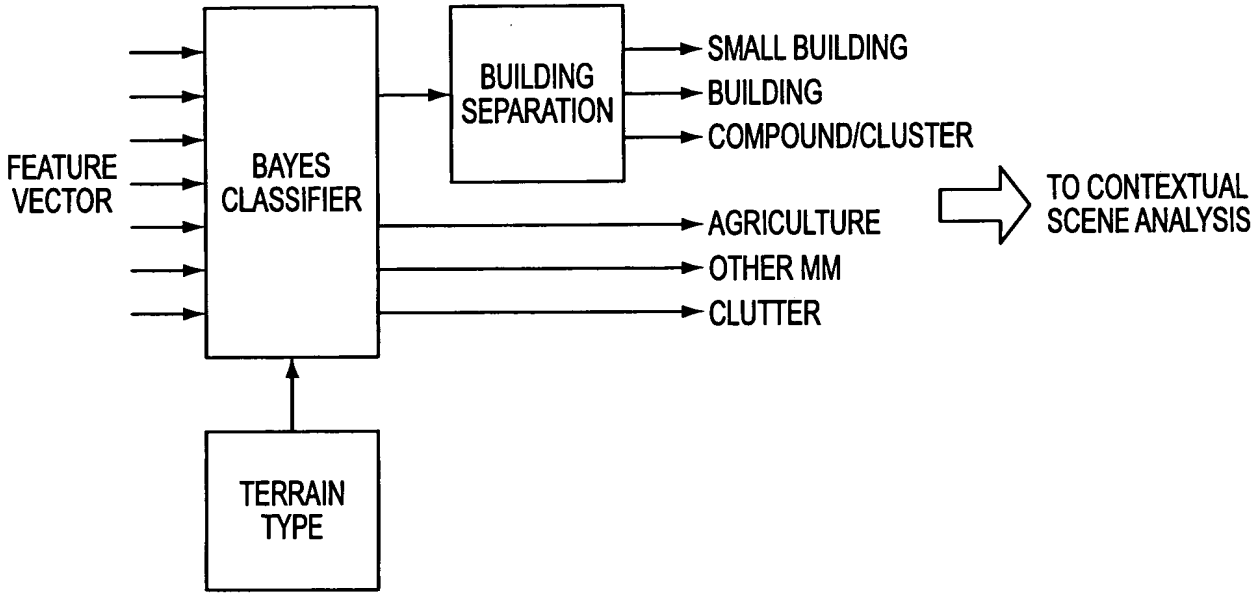

FEATURE VECTOR
BAYES CLASSIFIER
BUILDING SEPARATION
SMALL BUILDING
BUILDING
COMPOUND/CLUSTER
AGRICULTURE
OTHER MM
CLUTTER
TO CONTEXTUAL SCENE ANALYSIS
TERRAIN TYPE

FIG. 44

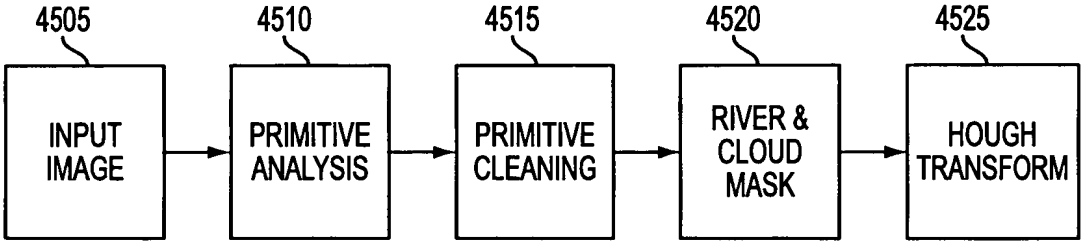

4505
4510
4515
4520
4525
INPUT IMAGE
PRIMITIVE ANALYSIS
PRIMITIVE CLEANING
RIVER & CLOUD MASK
HOUGH TRANSFORM

FIG. 45

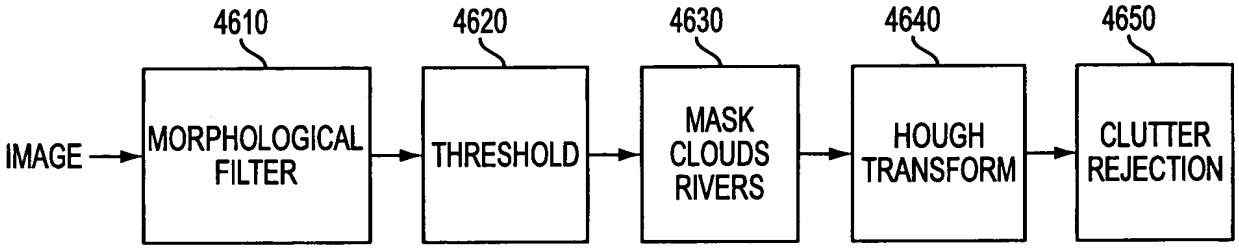


FIG. 46

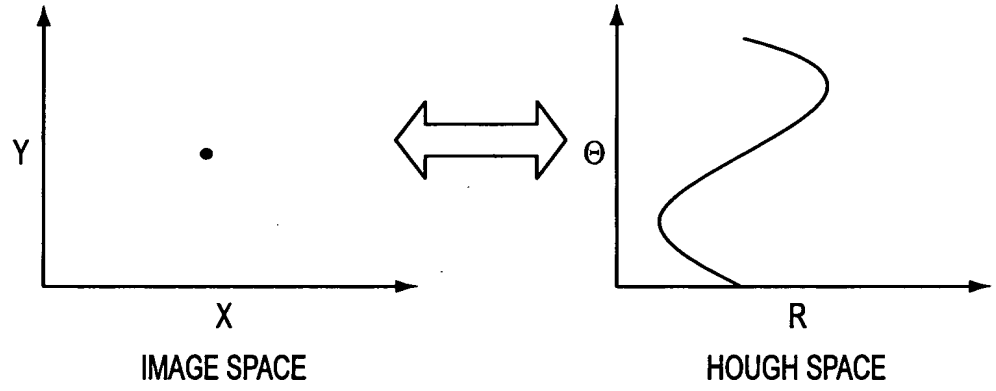


FIG. 47A

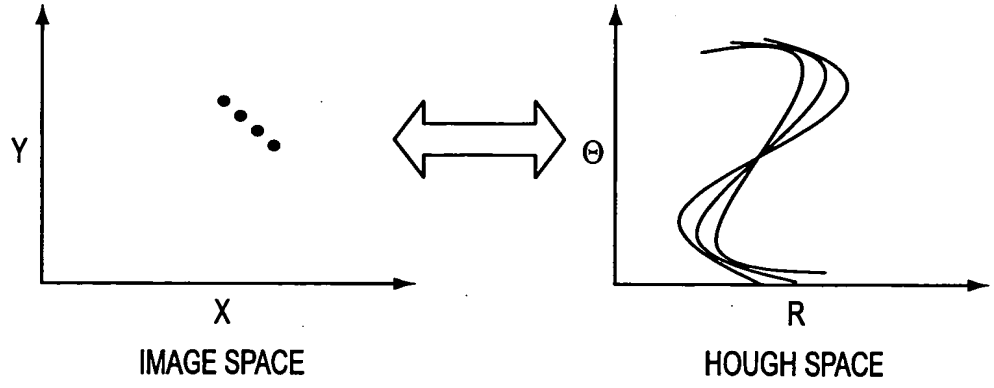


FIG. 47B

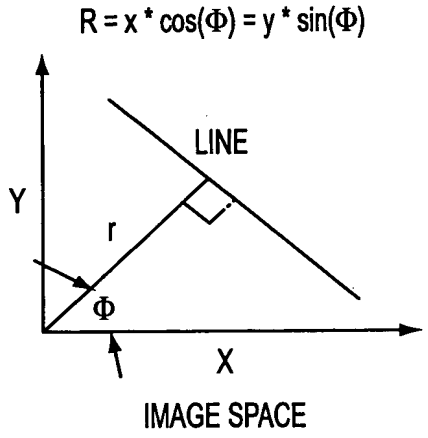

R = x * cos(Φ) = y * sin(Φ)
LINE
Y
r
Φ
X
IMAGE SPACE

FIG. 48

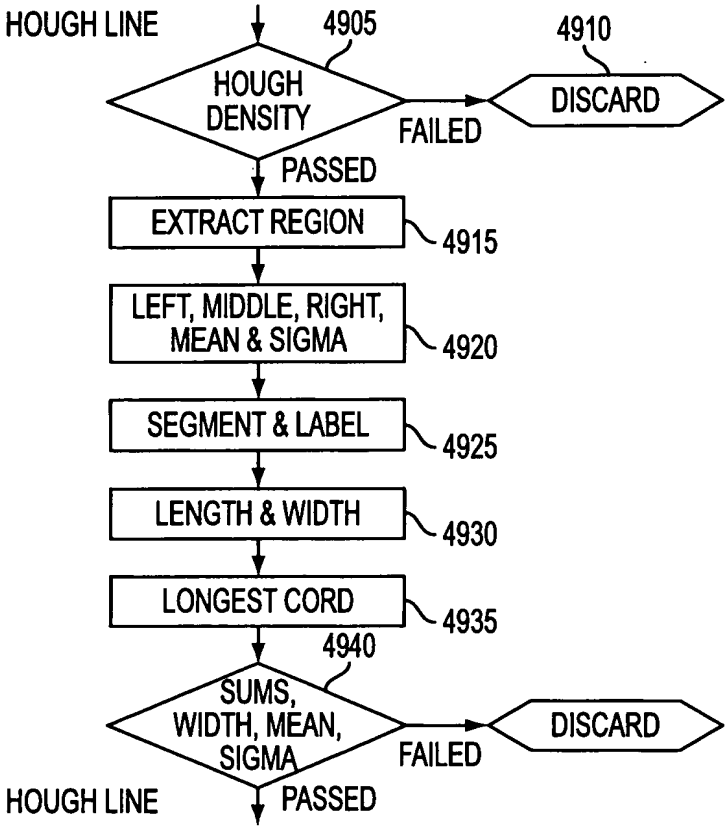

HOUGH LINE
4905
HOUGH DENSITY
FAILED
4910
DISCARD
PASSED
EXTRACT REGION
4915
LEFT, MIDDLE, RIGHT, MEAN & SIGMA
4920
SEGMENT & LABEL
4925
LENGTH & WIDTH
4930
LONGEST CORD
4935
4940
SUMS, WIDTH, MEAN, SIGMA
FAILED
DISCARD
HOUGH LINE
PASSED

FIG. 49

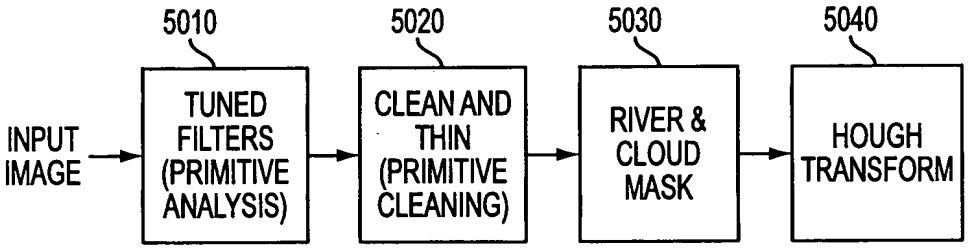


FIG. 50

A1	0	B1	0	C1
A2	0	B2	0	C2
A3	0	B3	0	C3
A4	0	B4	0	C4
A5	0	B5	0	C5
A6	0	B6	0	C6
A7	0	B7	0	C7
A8	0	B8	0	C8
A9	0	B9	0	C9
A10	0	B10	0	C10
A11	0	B11	0	C11
A12	0	B12	0	C12
A13	0	B13	0	C13
A14	0	B14	0	C14
A15	0	B15	0	C15

$$B_8 = 2 \times \sum_{i=1}^{15} B_i - \left(\sum_{i=1}^{15} A_i + \sum_{i=1}^{15} C_i \right)$$

FIG. 51

A1	A2	A3	A4	A5
A16	B1	B2	B3	A6
A15	B4	B5	B6	A7
A14	B7	B8	B9	A8
A13	A12	A11	A10	A9

FIG. 52

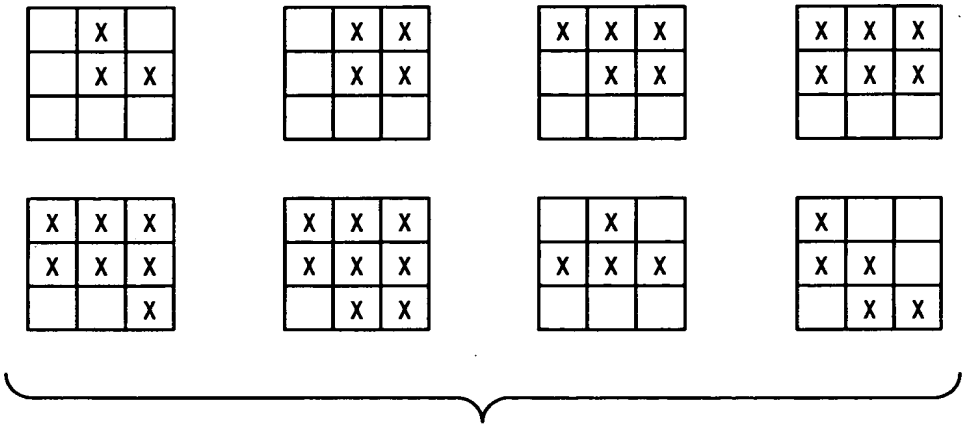


FIG. 53

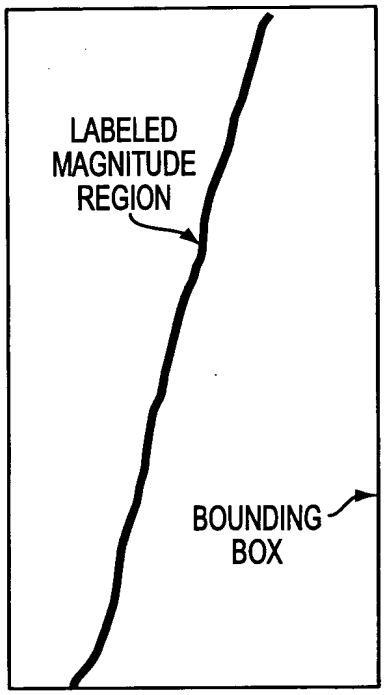

LABELED
MAGNITUDE
REGION
BOUNDING
BOX

FIG. 54

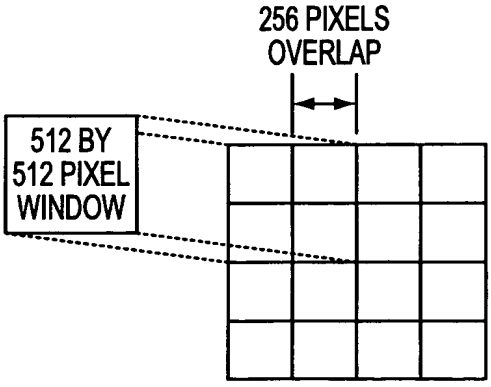

256 PIXELS
OVERLAP
512 BY
512 PIXEL
WINDOW

FIG. 55

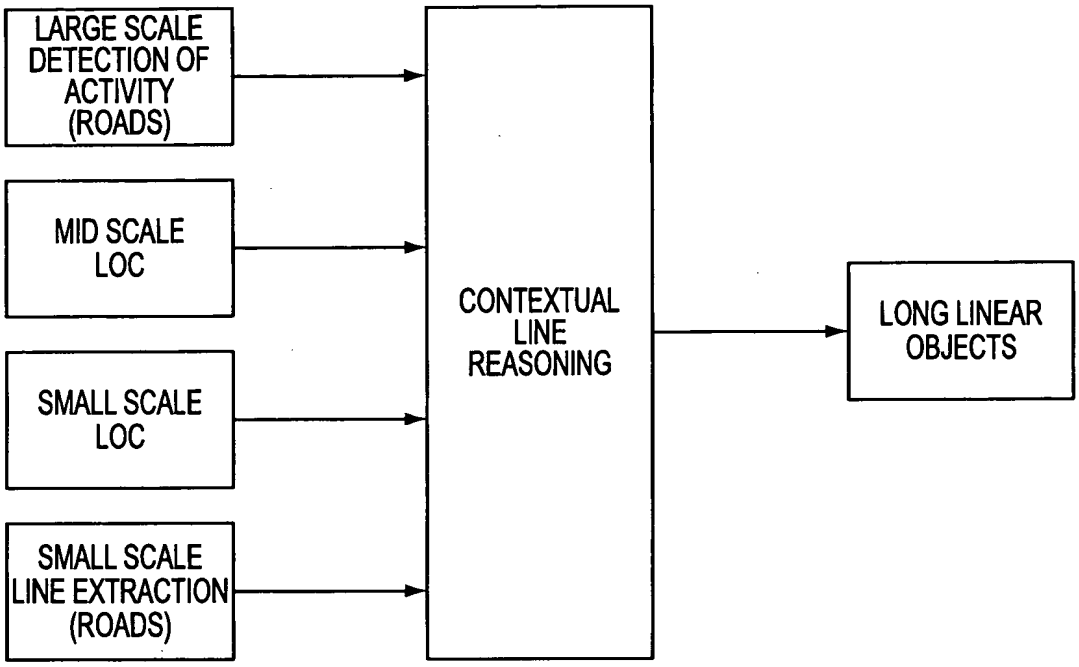

LARGE SCALE DETECTION OF ACTIVITY (ROADS)
MID SCALE LOC
SMALL SCALE LOC
SMALL SCALE LINE EXTRACTION (ROADS)
CONTEXTUAL LINE REASONING
LONG LINEAR OBJECTS

FIG. 56

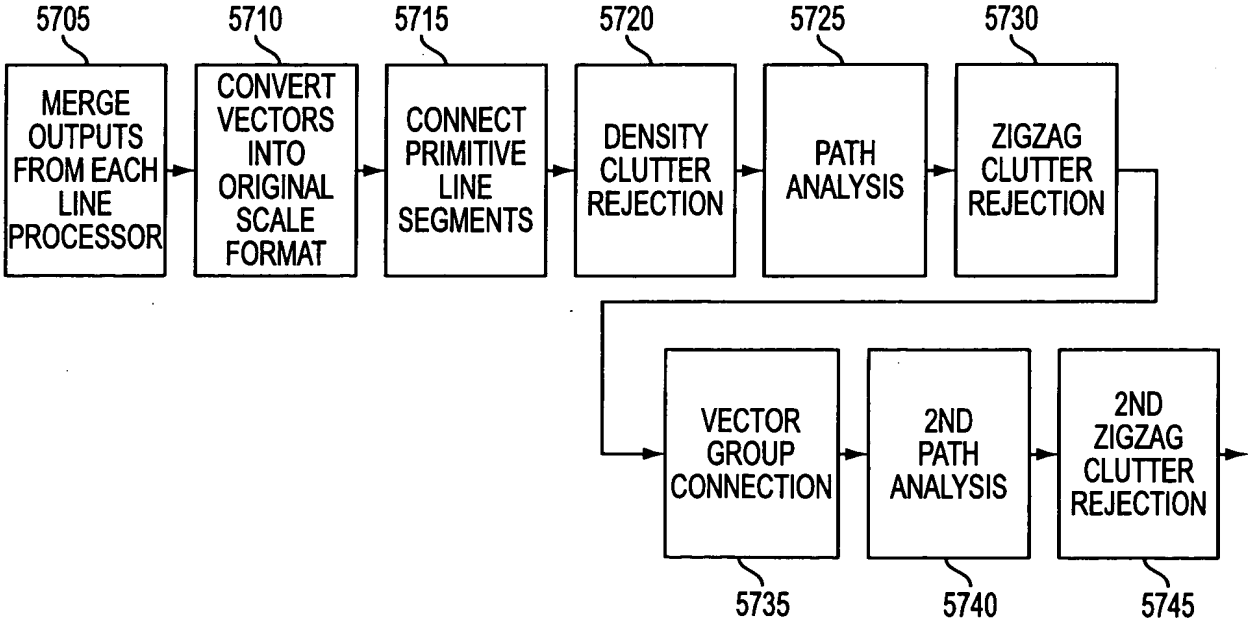

5705
MERGE OUTPUTS FROM EACH LINE PROCESSOR
5710
CONVERT VECTORS INTO ORIGINAL SCALE FORMAT
5715
CONNECT PRIMITIVE LINE SEGMENTS
5720
DENSITY CLUTTER REJECTION
5725
PATH ANALYSIS
5730
ZIGZAG CLUTTER REJECTION
VECTOR GROUP CONNECTION
5735
2ND PATH ANALYSIS
5740
2ND ZIGZAG CLUTTER REJECTION
5745

FIG. 57

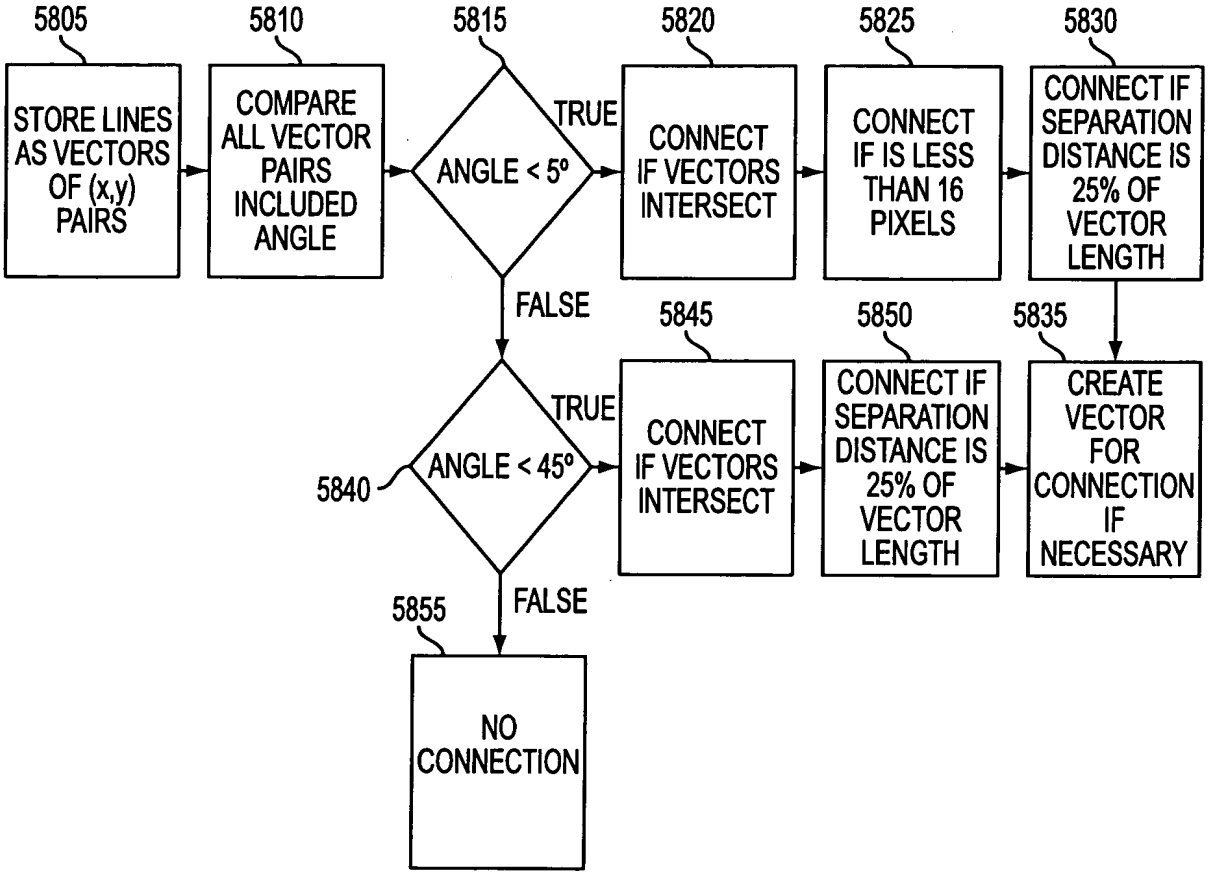


FIG. 58

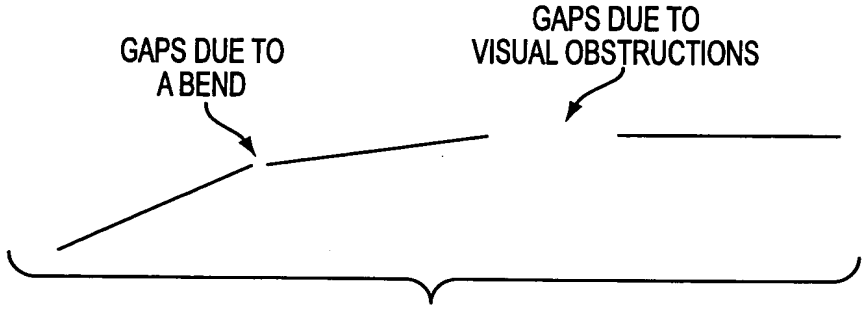


FIG. 59A

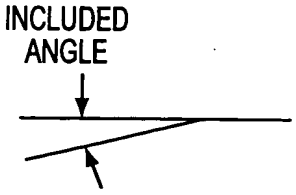


FIG. 59B

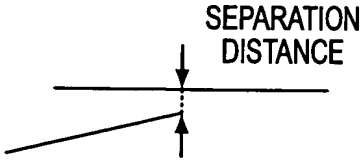


FIG. 59C

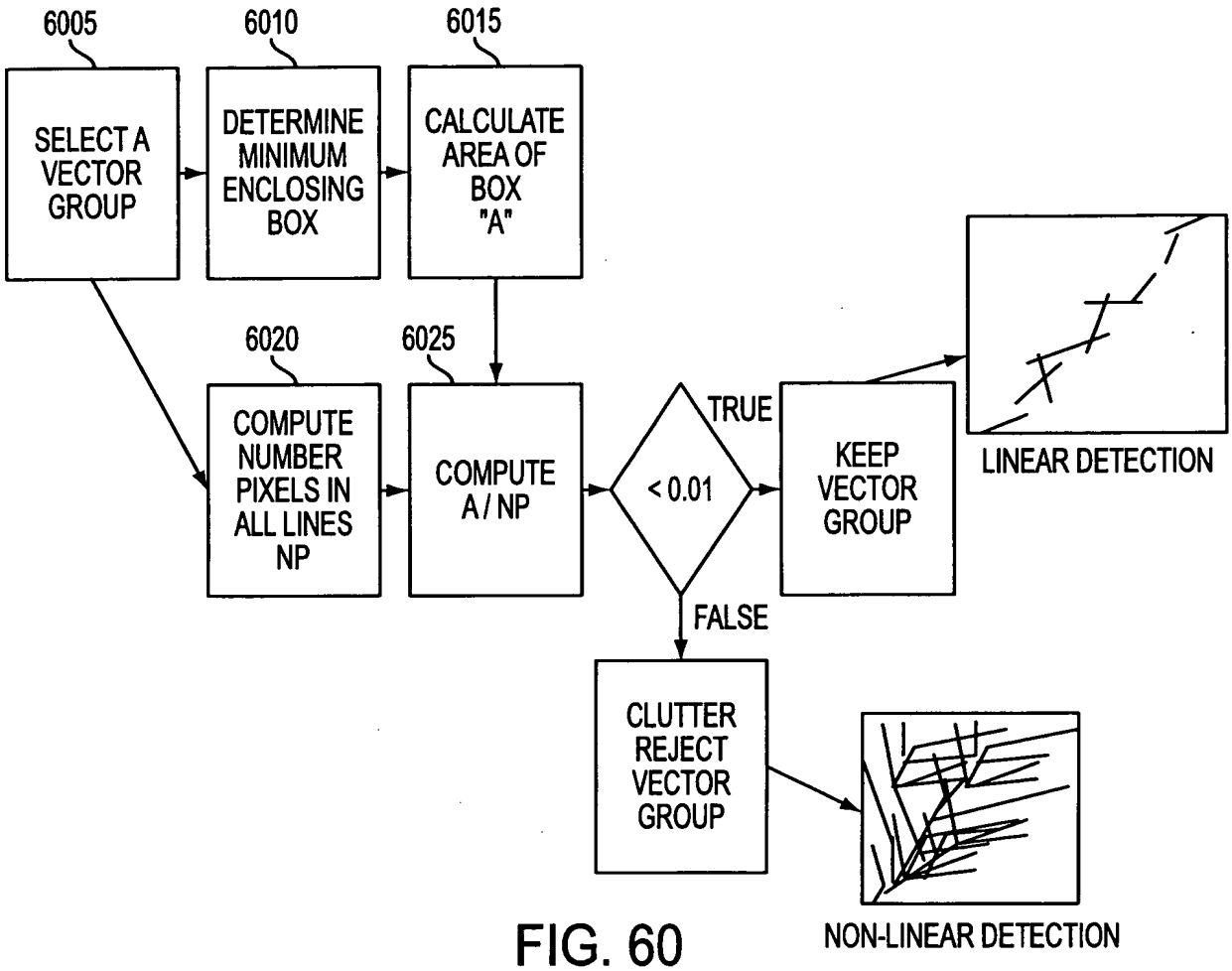


FIG. 60

$M^1 = \left\| m_{ij}^1 \right\|$ WHERE m_{ij}^1 IS THE DIRECT DISTANCE BETWEEN NODE i AND j IN PIXELS

$M^2 = \left\| m_{ij}^2 \right\|$ WHERE m_{ij}^2 IS THE DIRECT DISTANCE BETWEEN NODE i AND j IN PIXELS USING A MOST ONE INTERMEDIATE NODE

$M^2 = M^1 \otimes M^1$

$M^4 = M^2 \otimes M^2$

IN GENERAL THE FOLLOWING IS TRUE

$M^{n+m} = M^n \otimes M^m$

WHEN $M^t \equiv M^{t+\alpha}$ WHERE α IS A POSITIVE NUMBER

ALL PATHS ARE CONNECT

FIG. 61

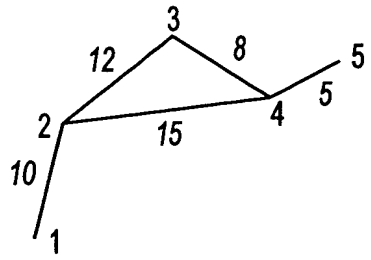


FIG. 62A

$$M^1 = \begin{matrix} 0 & 10 & 0 & 0 & 0 \\ x & 0 & 12 & 15 & 0 \\ x & x & 0 & 8 & 0 \\ x & x & x & 0 & 5 \\ x & x & x & x & 0 \end{matrix}$$

FIG. 62B

$$M^2 = \begin{matrix} 0 & 10 & 22 & 25 & 0 \\ x & 0 & 12 & 15 & 20 \\ x & x & 0 & 8 & 13 \\ x & x & x & 0 & 5 \\ x & x & x & x & 0 \end{matrix}$$

FIG. 62C

$$M^3 = \begin{matrix} 0 & 10 & 22 & 25 & 30 \\ x & 0 & 12 & 15 & 20 \\ x & x & 0 & 8 & 13 \\ x & x & x & 0 & 5 \\ x & x & x & x & 0 \end{matrix}$$

FIG. 62D

$M^3 = M^4$

FIG. 62E

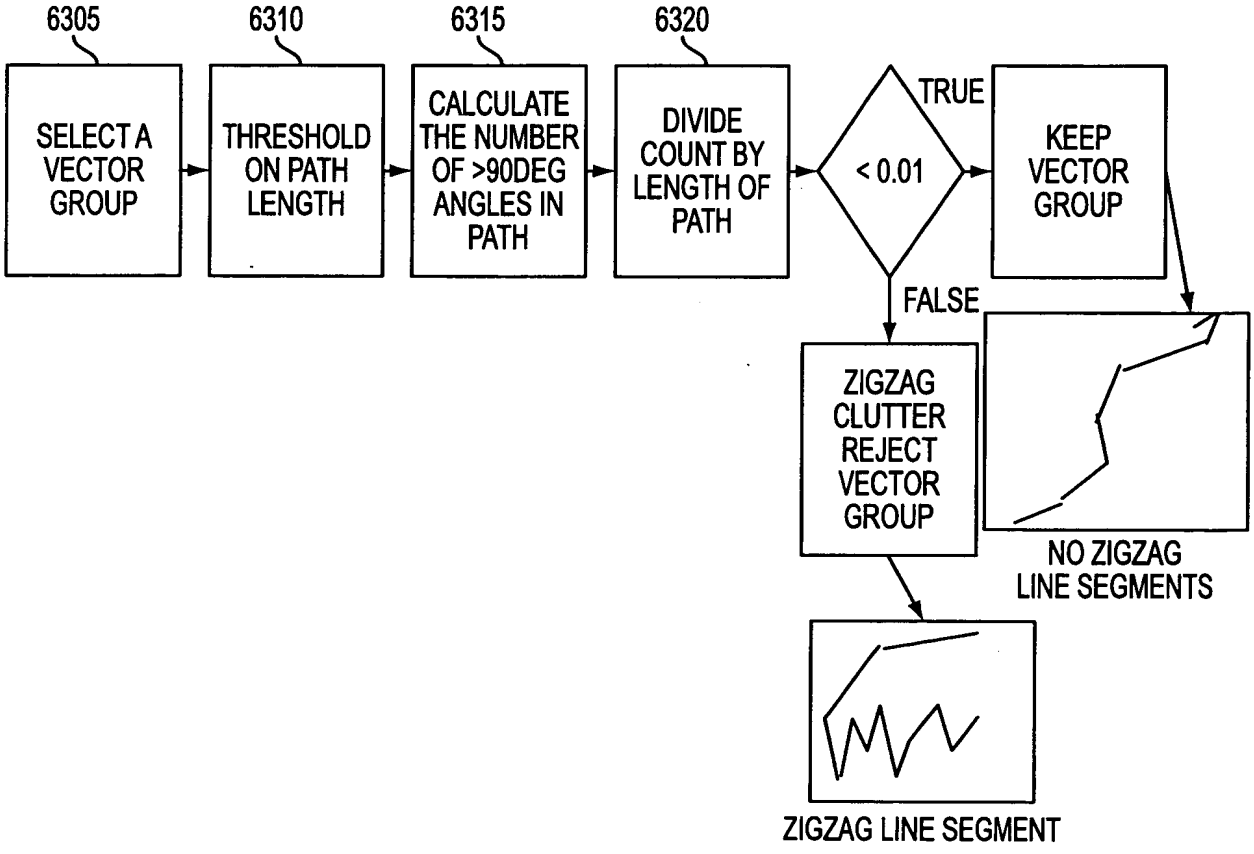


FIG. 63

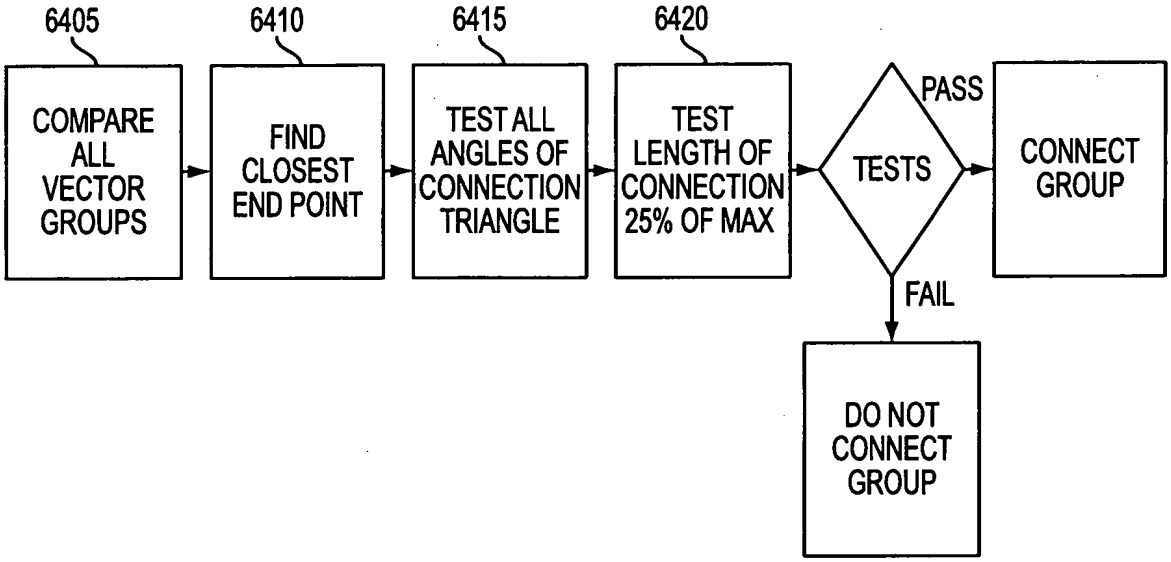

6405
6410
6415
6420
COMPARE ALL VECTOR GROUPS
FIND CLOSEST END POINT
TEST ALL ANGLES OF CONNECTION TRIANGLE
TEST LENGTH OF CONNECTION 25% OF MAX
TESTS
PASS
FAIL
CONNECT GROUP
DO NOT CONNECT GROUP

FIG. 64

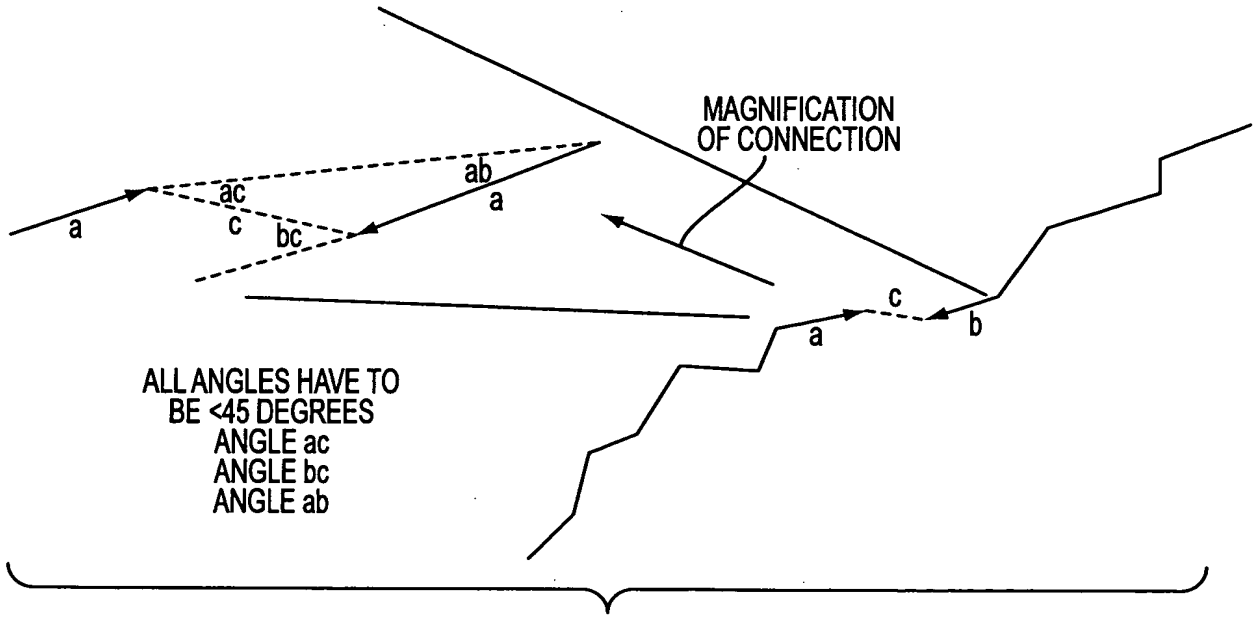

MAGNIFICATION OF CONNECTION
a
ac
c
bc
ab
a
c
a
b
ALL ANGLES HAVE TO BE <45 DEGREES
ANGLE ac
ANGLE bc
ANGLE ab

FIG. 65

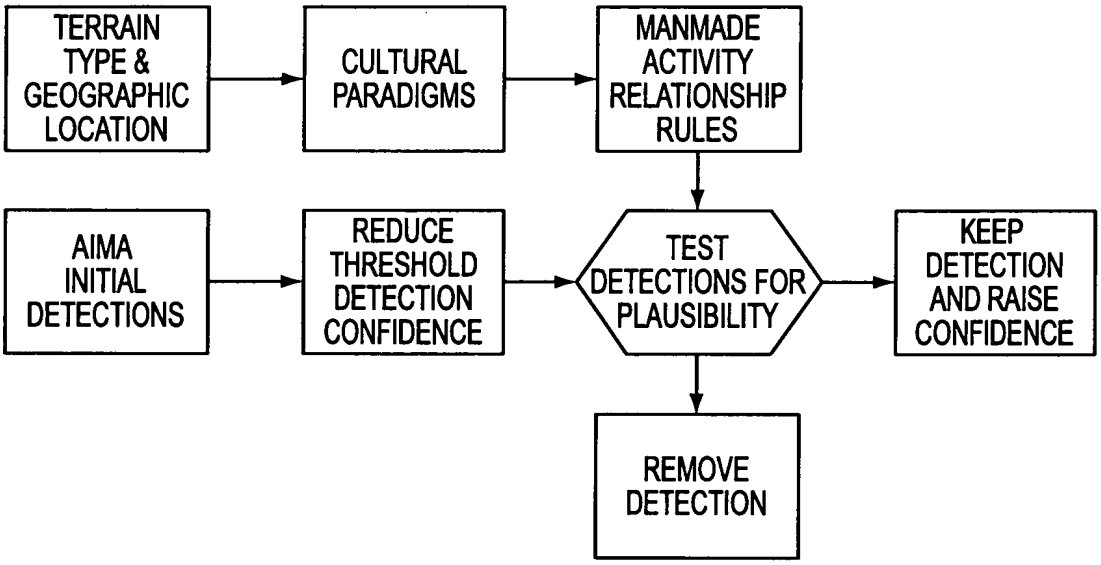

TERRAIN TYPE & GEOGRAPHIC LOCATION
CULTURAL PARADIGMS
MANMADE ACTIVITY RELATIONSHIP RULES
AIMA INITIAL DETECTIONS
REDUCE THRESHOLD DETECTION CONFIDENCE
TEST DETECTIONS FOR PLAUSIBILITY
KEEP DETECTION AND RAISE CONFIDENCE
REMOVE DETECTION

FIG. 66